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Review Article

Death cases involving certain new psychoactive substances: A review of the literature

Michael Kraemer*, Anna Boehmer, Burkhard Madea, Alexandra Maas

University of Bonn, Institute of Forensic Medicine, Stiftsplatz 12, 53111 Bonn, Germany

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ABSTRACT

In the last decades, more and more new psychoactive substances (NPS) were introduced on the drug market which were sold as "legal" alternatives for classic drugs and misused medications. Due to an increased number of available substances and a growing utilization by users of common drugs but also by inexperienced users because of the supposed "legal" status, also undesired adverse effects of these NPS, at worst leading to death, became apparent.

This review summarizes fatalities previously described in scientific literature which were attributed to the use of NPS or such cases, in which intake of NPS was proven or even assumed to contribute to death. This summary includes an overview of substances involved (particularly synthetic cannabinoids ("spice"), novel opioids and synthetic cathinones ("bath salts")) as well as of postmortem concentrations determined in various biological matrices. The compiled data assist forensic toxicologists with the interpretation of death cases involving NPS.

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1. Introduction

The number of new psychoactive substances (NPS) reported to the EU rapid alert system has increased steadily by 2014. While the number of notified synthetic cannabinoids or cathinones has decreased in recent years, the number of synthetic opioids is increasing. At the end of 2017, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) monitored more than 670 NPS traded on the European drug market [1]. Newly appearing NPS often need to be incorporated into national legislation to be monitored as controlled substances. Up to legislative change, it often takes several months up to years. Even legislation that establishes certain structural elements for controlled substances (e.g. the new psychoactive substances act (NpSG) in Germany) is often circumvented by structural modifications of substances.

The severe health hazard of these NPS becomes apparent by the large number of intoxications described in the literature. In Germany, 39 death cases in 2015 and 98 cases in 2016 were caused by "poisoning in combination with new psychoactive substances" [2]. Due to permanent changes in the drug market and the difficulty of NPS detection with routinely used analytical methods (e.g. general unknown screening), the estimated number is likely to be higher. Targeted analyses of NPS are often solely carried out if the environment of the deceased or circumstances at corpse discovery give evidence of NPS consumption.

* Corresponding author.
E-mail addresses: michael.kraemer@uni-bonn.de (M. Kraemer), anna-maria.boehmer@web.de (A. Boehmer), b.madea@uni-bonn.de (B. Madea), alexandramaas@uni-bonn.de (A. Maas).

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The aim of this work is to summarize fatalities described in scientific literature, which are associated with the consumption of NPS or for which an intake was confirmed analytically irrespective of its contribution to death. This review shall give an overview of substances involved in such cases as well as corresponding concentrations determined in various biological matrices and thus assisting forensic toxicologist with interpreting concentrations of NPS in upcoming death case investigations.

However, due to various influences, postmortem concentrations described in the following tables should be regarded with reservation. Furthermore, it should be considered that concentrations listed below are only individual values. Due to an impossible implementation of systematic studies (e.g. controlled administration of NPS to living humans) for ethical reasons, no concentration-effect relationships can be established for the substances.

2. Methods

Publications reporting fatalities involving an intake of NPS were searched in Google Scholar and PubMed using terms including "death", "fatal poisoning", "synthetic cannabinoid", "synthetic opioid", "synthetic cathinone", "bath salt", "synthetic benzodiazepine", "designer drug", "new psychoactive substance". Moreover, although previously not found in literature research, publications that were cited in those found in initial search were also considered.

3. Death cases due to certain new psychoactive substances

3.1. Synthetic cannabinoids ("Spice")

Synthetic cannabinoids are a group of substances that act agonistically at cannabinoid receptors CB_1 and CB_2 mimicking activity of tetrahydrocannabinol (THC) and thus causing cannabis-like effects including mood elevation, relaxation or euphoria [3,4]. In contrast to THC, many synthetic cannabinoids are direct agonists and have an increased affinity and potency at CB_1 receptor that mediates psychotropic cannabinoid effects [4–8]. Due to these properties, but possibly also other still unknown modes of action, the use of synthetic cannabinoids can lead to considerable psychotropic effects. The (undesired) effects described in the literature include, but are not limited to agitation, irritability, drowsiness, psychosis, paranoia, hallucinations, delusions, confusion, disorientation, aggression, altered mood and perception, loss of consciousness or memory, seizure, hypertension, tachycardia, chest pain, nausea, dizziness [3,4,9]. In addition, some effects associated with synthetic cannabinoid use are potentially life-threatening, for example cardiovascular effects (e.g. myocardial infarction) or acute kidney injury [3,9].

Even non-health related effects of synthetic cannabinoids may result in death. For example, the above-mentioned impairments of behavior or awareness may be risky of incomprehensible behavior patterns and associated accidents that are fatal due to injury or trauma. Also mixed intoxications with other centrally acting agents are conceivable [10].

For this reason, some cases have been described in the scientific literature in which (toxic) effects of synthetic cannabinoids are supposed to be causative for death or at least contributing to death. These cases and cases, in which an intake of synthetic cannabinoids was proven, are summarized in Table 1.

3.2. Novel opioids

Like other commonly used opioids, novel opioids act as full μ-opioid receptor agonists [11,12]. However, fentanyl analogues and other new synthetic opioids have variable potencies at the mentioned receptor [12]. Overdoses of novel opioids are comparable to those with traditional ones, causing symptoms including altered mental status, decreased consciousness, pinpoint pupils, bradycardia, hypotension, hypoxia and hypothermia and respiratory depression [11,12].

Particularly respiratory depression is a severe adverse health effect possibly leading to fatal outcome. Death cases associated with the use of novel opioids are summarized in Table 2.

3.3. Synthetic cathinones ("bath salts") and further NPS

Death cases involving further NPS, inter alia synthetic cathinones ("bath salts") or synthetic benzodiazepines, are summarized in Table 3.

Synthetic cathinones, also sold as bath salts", are chemical derivatives of cathinone, the active beta ketone amphetamine present in leaves of khat (*catha edulis*) [13,14]. Cathinone derivatives are phenalkylamine analogues with a β-keto group in the side chain [13]. Due to their structural similarity, cathinone derivatives cause amphetamine-like effects [11,13]. Activity of cathinone derivatives is based on mediation of monoamine (e.g. norepinephrine, dopamine and serotonin) release or reuptake inhibition [11,13]. Thus, intention of bath salt consumption is pre-eminently to enhance alertness as well as to improve mood [15]. Moreover, they are associated with increased energy, empathy, openness and libido [14]. Cathinone derivatives in general show psychostimulant and hallucinogenic properties [13]. Undesired effects include cardiovascular and gastrointestinal effects or complications regarding central nervous system [11,13]. Neurological effects comprise agitation, anxiety, paranoia, psychosis and headaches [11]. Moreover symptoms like hypertension, tachycardia, chest pain, hyperthermia, nausea and emesis were described [11]. Particularly, overdoses are associated with agitation, combative behavior, hallucinations, delusions, hyperthermia, tachycardia and hypertension [15]. User reported effects due to bath salts were classified into cardiovascular (e.g. palpitations), ear-nose-tongue-concerning (e.g. dry mouth), gastrointestinal, genitourinary, musculoskeletal, neurologic (e.g. aggressiveness, dizziness, memory loss, seizures), ophthalmologic, pulmonary, psychological (e.g. anxiety, auditory and visual hallucinations, paranoia) and other effects [14]. Effects of synthetic cathinones reported by medical providers (including emergency department and poison center data) also comprised cardiovascular, neurologic, pulmonary, psychological or renal (e.g. acute renal failure) effects [14].

These severe adverse health effects clarify the hazard originating from bath salt consumption possibly resulting in direct fatal poisoning or contributing to death by other means.

4. Discussion and conclusions

The determination of a fatal intoxication requires the quantitative detection of potentially death-causing substances and the exclusion of alternative causes of death [16]. Results of postmortem toxicological analyses should always be interpreted in context of the entirety of the individual case [17,18].

As for other xenobiotics, evaluation of toxicological significance of NPS in postmortem cases requires consideration of several aspects, for instance circumstances of death, disease prehistory, autopsy findings, postmortem drug concentration changes, assessment of substance tolerance (especially for opioids) of the deceased individual or interactions with other substances detected [19–21]. Providing substance concentrations of comparable cases (preferably with various circumstances) can be helpful for forensic toxicologists as to the question whether toxicological findings alone are responsible for death or at least contributed to death or whether toxicological findings are of minor importance for the determination of the cause of death.

Table 1
Death cases involving synthetic cannabinoids.

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
5F-ADB	male, 34 years old	Femoral vein, right and left heart blood	not detected	–	Asphyxia due to aspiration of stomach contents into trachea	[38]
		Stomach contents	3.18 ng/mL or g			
		Brain	1.90 ng/g			
		Lung, Liver, Kidney, Skeletal Muscle	<0.5 ng/g			
		Heart muscle	1.82 ng/g			
		Spleen	1.17 ng/g			
		Pancreas	1.61 ng/g			
		Adipose tissue	7.95 ng/g			
5F-ADB	male, 53 years old	Right heart blood	0.19 ng/mL	Diphenidine: 12 ng/mL (see Table 3)		[39]
5F-ADB	male	Urine	19 pg/mL	MAB-CHMINACA: 229 ng/mL (see Table 1)		[40]
5F-ADB	male	Iliac venous blood	0.12 ng/mL	–	Acute circulatory failure after drug inhalation	[41]
		Right heart blood	0.24 ng/mL			
		Left heart blood	0.45 ng/mL			
5F-ADB	male	Iliac venous blood	0.23 ng/mL		Acute circulatory failure after drug inhalation	[41]
		Right heart blood	1.35 ng/mL			
		Left heart blood	not available			
5F-ADB	male	Iliac venous blood	0.16 ng/mL	–	Acute circulatory failure after drug inhalation	[41]
		Right heart blood	0.14 ng/mL			
		Left heart blood	0.11 ng/mL			
5F-ADB	male	Iliac venous blood	1.38 ng/mL	–	Acute circulatory failure after drug inhalation	[41]
		Right heart blood	1.92 ng/mL			
		Left heart blood	not available			
5F-ADB	male, 49 years old	Femoral blood	approx. 0.20 ng/mL	Fentanyl: 5.5 ng/mL Quetiapine: 11.6 ng/mL 7-hydroxy-quetiapine: 8.2 ng/mL Oxycodone: 12.7 ng/mL Noroxycodone: 2.7 ng/mL Oxymorphone: 2.2 ng/mL	Polytrauma with leading craniocerebral injury	Unpublished Data, Institute of Forensic Medicine Bonn, Germany
5F-ADB	male, 46 years old	Femoral Blood	approx. 0.50 ng/mL	Opipramol: 89.1 ng/ml Mirtazapine: 48.4 ng/ml Desmethylmirtazapine: 19.4 ng/ml Promethazine: 275 ng/ml Gabapentin: 4.6 μg/ml Pregabalin: 0.7 μg/ml	Probably mixed drug intoxication, known epileptics	Unpublished Data, Institute of Forensic Medicine Bonn, Germany
5F-ADB	male, 59 years old	Femoral blood	approx. 0.14 ng/mL	Alcohol: 1,89 ‰ Amitriptyline: 88.0 ng/ml Nortriptyline: 22.0 ng/ml	Probably mixed drug intoxication	Unpublished Data, Institute of Forensic Medicine Bonn, Germany
5F-ADB	male, 31 years old	Femoral blood	approx. 0.57 ng/mL	JWH-122: approx. 12 ng/mL (see Table 1) Diphenhydramine: <10 ng/mL (approx. 4.7 ng/mL) Doxylamine: 83.5 ng/mL	Probably mixed drug intoxication with JWH-122, 5F-ADB and doxylamine in case of preexisting heart disease	Unpublished Data, Institute of Forensic Medicine Bonn, Germany
		Urine	metabolites positive	JWH-122: metabolites positive (see Table 1) JWH-018: metabolites positive (see Table 1) MDMB-CHMICA: metabolites positive (see Table 1) Diphenhydramine: 232 ng/mL Doxylamine: >500 ng/ml (approx. 1570 ng/ml)		

5F-ADB	male, 41 years old	Femoral blood	0.38 ng/mL	Blood: Alcohol: 0.09 g/kg Trimipramine: 0.17 μg/mL Olanzapine: 41 ng/mL Urine: Alcohol: 0.12 g/kg Trimipramine: 0.10 μg/mL Metabolites of 5F-ADB, NE-CHMIMO and MDMB-CHMICA: positive Stomach content: Trimipramine: 28 μg/mL	Assumed that consumption of 5F-ADB led to coma and subsequent aspiration of vomit	[42]
5F-AMB	male, 30 years old	Femoral vein blood, right and left heart blood, urine, brain, heart muscle, lung, liver, spleen, kidney, pancreas	not detected	AB-CHMINACA (see Table 1) Diphenidine (see Table 2)	Poisoning by multiple drugs	[43]
		Adipose tissue	18.7 ng/g			
5F-AMB	male, 25 years old	Femoral venous blood	0.19 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	<0.1 ng/mL			
5F-AMB	male, 34 years old	Subclavian vein blood	0.3 ng/mL	–	Accidental death due to synthetic cannabinoid toxicity	[45]
5F-AMB	male	Urine	19 pg/mL	AB-CHMINACA: 232 pg/mL (see Table 1)		[40]
5F-APINACA	male, 25 years old	Femoral venous blood	0.51 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	<0.1 ng/mL			
5F-APINACA	male, 24 years old	Femoral blood	<0.1 ng/mL	MT-45 (see Table 2) Femoral blood and stomach contents: Lidocaine: positive Femoral blood: PB-22: <0.1 ng/mL (see Table 1) Femoral blood, urine and stomach contents: Methoxmetamine: presence indicated	By exclusion of other causes of death, attributed to consumption of an MT-45 overdose	[46]
5F-PB-22	male, 17 years old	Femoral (postmortem) blood	1.1 ng/mL	Alcohol: 0.33 g/L Amiodarone (administration during resuscitative procedures): positive Caffeine: positive	5F-PB-22 intoxication	[47]
5F-PB-22	male, 27 years old	Serum samples (antemortem, collected a day before death in an interval of approx. 9.5 h)	not tested	THC-COOH: 246 ng/mL and 176 ng/mL Piperacillin: positive Levofloxacin: positive	Fulminant liver failure	[47]
		Serum (antemortem, collected 7 h before death)	1.3 ng/mL	Lorazepam: 19.5 ng/mL		

Table 1 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
5F-PB-22	male, 18 years old	Iliac (postmortem) blood	1.5 ng/mL	–	Sudden death, in association with synthetic cannabinoid use	[47]
5F-PB-22	male, 19 years old	Superior vena cava (postmortem) blood	1.5 ng/mL	–	Acute drug intoxication using 5F-PB-22	[47]
5F-PB-22	male, 25 years old	Femoral blood	0.37 ng/mL	Blood: Alcohol: 2.60 g/kg Urine: Alcohol: 3.58 g/kg 5F-PB-22 3-carboxyindole (5F-PB-22 metabolite): positive PB-22 5-hydroxy-pentyl (5F-PB-22 metabolite): positive PB-22 5-pentanoic acid (5F-PB-22 metabolite): positive	Suffocation after partial or complete blocking of the upper airways in the presence of 5F-PB-22 and ethanol (probably in a state of unconsciousness)	[42]
AB-CHMINACA	male, 30 years old	Femoral vein blood	<1 ng/mL	5F-AMB (see Table 1) Diphenidine (see Table 3)	Poisoning by multiple drugs	[43]
		Right and left heart blood, urine	not detected			
		Brain	15.6 ng/g			
		Heart muscle	20.0 ng/g			
		Lung	8.02 ng/g			
		Liver	21.2 ng/g			
		Spleen	7.55 ng/g			
		Kidney	24.7 ng/g			
		Pancreas	38.9 ng/g			
		Adipose tissue	24.8 ng/g			
AB-CHMINACA	male, 25 years old	Femoral venous blood	2.8 ng/mL	AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	1.1 ng/mL			
AB-CHMINACA	male, 45 years old	Heart blood	7.2 ng/mL	–	Accidental drug overdose by synthetic cannabinoid	[48] (abstract only)
AB-CHMINACA	female, 24 years old	Heart blood	3.4 ng/mL	Norfluoxetine: 368 ng/mL	Accidental AB-CHMINACA intoxication in the setting of a motor vehicle collision	[48] (abstract only)
AB-CHMINACA	male, 28 years old	Heart blood	10 ng/mL	Alprazolam: 64.2 ng/mL	Injuries sustained from motor vehicle accident in the setting of AB-CHMINACA and alprazolam	[48] (abstract only)
AB-CHMINACA	male, 23 years old	Femoral blood	7.0 ng/mL	Femoral blood: Caffeine: positive Cotinine: positive		[49] (abstract only)
		Heart blood	16.9 ng/mL			
		Urine	mono-hydroxyl metabolite positive			
		Gastric	59.2 ng/40 mL			
		Vitreous	negative			
		Bile	46.7 ng/mL			
		Liver	404 ng/g			

AB-CHMINACA	female, 33 years old	Femoral blood	7.1 ng/mL	Femoral blood: Methadone: 167 ng/mL EDDP: 29.6 ng/mL Diphenhydramine: < 0.05 mg/L β-phenethylamine: positive Cotinine: positive		[49] (abstract only)
		Heart blood	7.8 ng/mL			
		Liver	115 ng/g			
		Kidney	26.5 ng/g			
		Brain	21.3 ng/g			
		Hair	positive			
AB-CHMINACA	male	Urine	232 pg/mL	5F-AMB: 19 pg/mL (see Table 1)		[40]
AB-CHMINACA	male, 28 years old	Femoral blood	approx 4.1 ng/mL	Blood: Alcohol: 1.45 g/kg Urine: Alcohol: 2.57 g/kg AB-CHMINACA metabolites: positive	Intoxication with AB-CHMINACA in the presence of ethanol	[42]
AB-FUBINACA	male, 25 years old	Femoral venous blood	0.97 ng/mL	AB-CHMINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	not detected			
AB-FUBINACA	male	Urine	10 pg/mL	AB-PINACA: 23 pg/mL (see Table 1)		[40]
AB-PINACA	male, 19 years old	Blood	32.8 ng/mL	THC: 1.1 ng/mL THC-COOH: 14.5 ng/mL Ethanol: 0.147%	Synthetic cannabinoid-related	[50] (abstract only)
AB-PINACA	male, 37 years old	Iliac blood	12.2 ng/mL	Ethanol: 0.171%	Synthetic cannabinoid-related	[50] (abstract only)
AB-PINACA	male	Urine	23 pg/mL	AB-FUBINACA: 10 pg/mL (see Table 1)		[40]
ADB-FUBINACA	female, 41 years old	Blood (inferior vena cava)	7.3 ng/mL	THC: 1.1 ng/mL THC-COOH: 4.7 ng/mL	Coronary arterial thrombosis in combination with synthetic cannabinoid use; accident	[51]
AM-2201	male, 25 years old	Femoral venous blood	<0.1 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	not detected			
AM-2201	male, 41 years old	Blood	2.5 ng/mL	JWH-018: 0.11 ng/mL (see Table 1) Phenytoin 8.8 μg/mL	Complications of excited delirium associated with synthetic marijuana use	[10]
AM-2201	male, 25 years old	Blood	0.21 ng/mL	JWH-018: 0.65 ng/mL (see Table 1) JWH-122: positive (see Table 1) JWH-210: positive (see Table 1) Ethanol: 0.15% w/v THC: 1.1 ng/mL THC-COOH: 6.0 ng/mL	Complications of acute ethanol toxicity, acute synthetic cannabinoid toxicity, possible hypothermia; accident	[10]

Table 1 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
AM-2201	male, 24 years old	Blood	0.16 ng/mL	JWH-122: positive (see Table 1) JWH-210: positive (see Table 1) THC: 2.7 ng/mL THC-COOH: 6.4 ng/mL Caffeine: positive Nicotine: positive Cotinine: positive	Adverse effects of AM-2201, JWH-122 and JWH-210	[10]
AM-2201	male, 55 years old	Blood	17 ng/mL	JWH-018: 0.47 ng/mL (see Table 1) Benzodiazepines: presump. positive Chlorpheniramine: <100 ng/mL Paroxetine: positive Alprazolam: <50 ng/mL Aripiprazole: positive	Ischemic heart disease, obesity, diabetes, synthetic cannabinoid toxicity	[10]
AM-2201	male, 24 years old	Blood	1.1 ng/mL	JWH-210: positive (see Table 1) Fluoxetine: 620 ng/mL Norfluoxetine: 520 ng/mL Phenobarbital: positive Benzodiazepines: positive Diphenhydramine: positive Methadone: positive	Mixed drug toxicity (methadone, phenobarbital and synthetic cannabinoids)	[10]
AM-2201	female, 42 years old	Blood	2.8 ng/mL	JWH-018: 0.11 ng/mL (see Table 1) Carbon monoxide: 4.3 μg/mL Iron: 74 mg/dL Caffeine: positive Cotinine: positive	Drug (synthetic cannabinoid toxicity); accident	[10]
AM-2201	male, 25 years old	Blood	7.3 ng/mL	JWH-122: positive (see Table 1) JWH-250: 0.23 ng/mL (see Table 1) Caffeine: positive Theobromine: positive Nicotine: positive Cotinine: positive	Adverse effects of drugs; accident	[10]
AM-2201	male, 25 years old	Blood	0.22 ng/mL	JWH-122: positive (see Table 1) JWH-210: positive (see Table 1)	Anoxic brain injury due to synthetic cannabinoid toxicity; accident	[10]
AM-2201	male, 55 years old	Blood	0.13 ng/mL	Hydrocodone: <20 ng/mL	Hypertensive heart disease, blunt force injuries to the head, synthetic cannabinoids present	[10]
AM-2201	male, 36 years old	Femoral blood	1.4 ng/mL	JWH-018 (see Table 1) JWH-122 (see Table 1) JWH-210(see Table 1) MAM-2201 (see Table 1) UR-144 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Brain	approx. 0.1 ng/g			
		Lung	Approx. 2.0 ng/g			
		Liver, Kidney	not detected			
		Bile fluid	approx. 5.9 ng/mL			
		Gastric contents	approx. 270 μg			
		Hair	approx. 3.0 ng/mg			
		Adipose tissue	approx. 180 ng/g			
AM-2201	male, 23 years old	Femoral blood	0.0002 μg/g	Femoral blood: 5-(2-aminopropyl) indole (5-IT or 5-API): 18.6 μg/g (see Table 3) Urine: 4-(2-aminopropyl) benzofuran (4-APB): positive	Intoxication by 5-IT and 4-APB; accident	[53]

EAM-2201	male, 25 years old	Femoral venous blood	<0.1 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	<0.1 ng/mL			
JWH-018	male, 41 years old	Blood	0.11 ng/mL	AM-2201: 2.5 ng/mL (see Table 1) Phenytoin 8.8 μg/mL	Complications of excited delirium associated with synthetic marijuana use	[10]
JWH-018	male, 25 years old	Blood	0.65 ng/mL	AM-2201: 0.21 ng/mL (see Table 1) JWH-122: positive (see Table 1) JWH-210: positive (see Table 1) Ethanol: 0.15% w/v THC: 1.1 ng/mL THC-COOH: 6.0 ng/mL	Complications of acute ethanol toxicity, acute synthetic cannabinoid toxicity, possible hypothermia; accident	[10]
JWH-018	male, 55 years old	Blood	0.47 ng/mL	AM-2201: 17 ng/mL (see Table 1) Benzodiazepines: presump. positive Chlorpheniramine: <100 ng/mL Paroxetine: positive Alprazolam: <50 ng/mL Aripiprazole: positive	Ischemic heart disease, obesity, diabetes, synthetic cannabinoid toxicity; natural	[10]
JWH-018	female, 42 years old	Blood	0.11 ng/mL	AM-2201: 2.8 ng/mL (see Table 1) Carbon monoxide: 4.3 μg/mL Iron: 74 mg/dL Caffeine: positive Cotinine: positive	Drug (synthetic cannabinoid toxicity); accident	[10]
JWH-018	male, 52 years old	Blood	0.28 ng/mL	Chlordiazepoxide: 2000 ng/mL Nordiazepam: 750 ng/mL Norchlordiazepoxide: positive Demoxepam: positive Oxazepam: trace detected	Multiple blunt force injuries; accident	[10]
JWH-018	male, 36 years old	Femoral blood	0.1 ng/mL	JWH-122 (see Table 1) JWH-210 (see Table 1) AM-2201 (see Table 1) MAM-2201 (see Table 1) UR-144 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Brain, lung, liver, kidney, bile fluid Gastric contents Adipose tissue Hair	not detected approx. 9.0 μg approx. 30 ng/g approx. 0.05 ng/mg			
JWH-018	male, 57 years old	Cardiac blood	199 ng/mL	Clonazepam: 5.5 ng/mL 7-aminoclonazepam: 56.6 ng/mL Methadone: 887 ng/mL EDDP: 115 ng/mL Morphine: 122 ng/mL Pregabalin: 1.8 mg/mL Topiramate: 4.1 mg/mL Naloxone: positive (administered during resuscitation efforts)		[54]
JWH-018	male, 52 years old	Cardiac blood	19.6 ng/mL	JWH-073: 68.3 ng/mL (see Table 1)		[54]
JWH-018	male, 29 years old	Cardiac blood	83.3 ng/mL	–	Suicide by exsanguination	[54]

Table 1 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
JWH-018	N=18	Blood	0.1-199 ng/mL			[54]
JWH-073	male, 52 years old	Cardiac blood	68.3 ng/mL	JWH-018: 19.6 ng/mL (see Table 1)		[54]
JWH-073	N=8	Blood	0.1-68.3 ng/mL			[54]
JWH-122	male, 25 years old	Femoral venous blood	<0.1 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) MAM-2201 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	<0.1 ng/mL			
JWH-122	male, 36 years old	Femoral blood	0.39 ng/mL	JWH-018 (see Table 1) JWH-210 (see Table 1) AM-2201 (see Table 1) MAM-2201 (see Table 1) UR-144 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Brain	traces			
		Lung	approx. 1.3 ng/g			
		Liver, kidney	not detected			
		Bile fluid	approx. 2.0 ng/mL			
		Gastric contents	approx. 8.5 μg			
		Hair	approx. 0.05 ng/mg			
		Adipose tissue	approx. 200 ng/g			
JWH-122	male, 31 years old	Femoral blood	approx. 12 ng/mL	5F-ADB: approx. 0.57 ng/mL (see Table 1) Diphenhydramine: <10 ng/mL (approx. 4.7 ng/mL) Doxylamine: 83.5 ng/mL	Probably mixed drug intoxication with JWH-122, 5F-ADB and doxylamine in case of preexisting heart disease	Unpublished Data, Institute of Forensic Medicine Bonn, Germany
		Urine	metabolites positive	5F-ADB: metabolites positive (see Table 1) JWH-018: metabolites positive (see Table 1) MDMB-CHMICA: metabolites positive (see Table 1) Diphenhydramine: 232 ng/mL Doxylamine: >500 ng/ml (approx. 1570 ng/ml)		
JWH-175	female, 31 years old	Blood	105 ng/mL	MDEA: 217 ng/mL MDA: 111 ng/mL	Multiple blunt traumatic injuries. Other conditions: Acute mixed drug intoxication; accident	[10]
JWH-210	male, 36 years old	Femoral blood, brain, lung, liver, kidney, bile fluid, gastric contents	not detected	JWH-018 (see Table 1) JWH-122 (see Table 1) AM-2201 (see Table 1) MAM-2201 (see Table 1) UR-144 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Hair	approx. 0.01 ng/mg			
		Adipose tissue	approx. 53 ng/g			

JWH-250	male, 25 years old	Blood	0.23 ng/mL	JWH-122: positive (see Table 1) AM-2201: 7.3 ng/mL (see Table 1) Caffeine: positive Theobromine: positive Nicotine: positive Cotinine: positive	Adverse effects of drugs; accident	[10]
MAB-CHMINACA (ADB-CHMINACA)	male	Urine	229 pg/mL	5F-ADB: 19 pg/mL (see Table 1)		[40]
MAM-2201	male, 25 years old	Femoral venous blood	<0.1 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) STS135 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	not detected			
MAM-2201	male, 59 years old	Whole blood	12.4 ng/mL	–	Acute intoxication with MAM-2201	[55]
		Liver	18.1 ng/g			
		Kidney	11.2 ng/g			
		Brain	4.3 ng/g			
		Adipose tissue	1535 ng/g			
MAM-2201	male, 36 years old	Femoral blood	1.5 ng/mL	JWH-018 (see Table 1) JWH-122 (see Table 1) JWH-210 (see Table 1) AM-2201 (see Table 1) UR-144 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Brain	approx. 0.7 ng/g			
		Lung	approx. 9.1 ng/g			
		Liver	not detected			
		Kidney	approx. 1.3 ng/g			
		Bile fluid	approx. 32 ng/mL			
		Gastric contents	approx. 780 μg			
		Hair	approx. 13 ng/mg			
		Adipose tissue	approx. 1800 ng/g			
MDMB-CHMICA	male, 25 years old	Antemortem blood (collected approx. 2 h after use of "Mocarz" herbal mixture)	5.6 ng/mL	Alcohol: antemortem blood: 1.48 g/L postmortem blood: 0.81 g/L	Multiple organ failure	[56]
		Postmortem blood and bile	<0.2 ng/mL			
		Brain	approx. 2.6 ng/g			
		Stomach	approx. 0.2 ng/g			
		Kidney	approx. 0.2 ng/g			
		Liver	positive			
MDMB-CHMICA	male, 22 years old	Serum (obtained approx. 2 h after victim was found; died the following day)	1.4 ng/mL	Serum: Mirtazapine: 5.3 ng/mL THC: 1.5 ng/mL Cetirizine: positive	Anoxic brain damage and pneumonia, overdose of MDMB-CHMICA	[57]
		Splenic tissue	0.1 ng/mL			

Table 1 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
N-1-naphthalenyl-1-pentyl-1H-indole-3-carboxamide (NNEI)	male	Blood (right and left atrium (plasma), right and left atrium (whole blood), right and left femoral vein (whole blood))	0.64-0.99 ng/mL	–	Probably acute circulatory disturbance induced by NNEI poisoning	[58]
		Urine	not detected			
		Brain	0.76 ng/g			
		Heart	0.82 ng/g			
		Lung	1.06 ng/g			
		Liver	1.31 ng/g			
		Kidney	0.92 ng/g			
		Abdominal subcutaneous adipose tissue	42.9 ng/g			
		Hair (concentrations of various segments, external contamination could not be excluded)	163-781 pg/mg			
PB-22	male, 24 years old	Femoral blood	<0.1 ng/mL	MT-45 (see Table 2) Femoral blood and stomach contents: Lidocaine: positive Femoral blood: 5F-AKB-48 (5F-APINACA): <0.1 ng/mL (see Table 1) Femoral blood, urine and stomach contents: Methoxmetamine: presence indicated	By exclusion of other causes of death, attributed to consumption of an MT-45 overdose	[46]
STS135	male, 25 years old	Femoral venous blood	0.16 ng/mL	AB-CHMINACA (see Table 1) AB-FUBINACA (see Table 1) AM-2201 (see Table 1) 5F-AMB (see Table 1) 5F-APINACA (see Table 1) ÊAM-2201 (see Table 1) JWH-122 (see Table 1) MAM-2201 (see Table 1) THJ 2201 (see Table 1) Urine: Metabolites of XLR-11 or UR-144: positive	Diabetic ketoacidosis	[44]
		Heart blood	not detected			
THJ 2201	male, 25 years old	Femoral venous blood	0.16 ng/mL		Diabetic ketoacidosis	[44]
		Heart blood	not detected			
UR-144	male, 36 years old	Femoral blood	approx. 6 ng/mL	JWH-018 (see Table 1) JWH-122 (see Table 1) JWH-210 (see Table 1) AM-2201 (see Table 1) MAM-2201 (see Table 1) Amphetamine: 250 ng/mL		[52]
		Brain, lung, liver, kidney	not detected			
		Bile Fluid	approx. 11 ng/mL			
		Gastric contents	approx. 50 μg			
		Hair	approx. 0.7 ng/mg			
		Adipose tissue	approx. 800 ng/g			

XLR-11	female, 29 years old	Peripheral blood	1.4 ng/mL	Diphenhydramine: 81.0 ng/mL	Synthetic cannabinoid toxicity; accident	[59]
XLR-11	female, 32 years old	Postmortem blood	0.6 ng/mL	Naloxone: presump. positive (administered during resuscitative attempts) Caffeine: presump. positive	Undetermined	[59]

However, due to the challenges described, concentrations should always be used with caution and having regard to all available circumstances. Contrary to classification of plasma concentrations (therapeutic, toxic, comatose fatal) as used for interpretation in clinical toxicology, in compliance assessment or for therapeutic drug monitoring (e.g. [22,23]), postmortem drug concentrations can hardly be classified (e.g. solely responsible for death, contributory to death, insignificant for death), especially not for NPS that are in general less examined that common drugs. The incorrectness of such a classification and as a result the risk of misleading interpretations can be illustrated using dying types according to Leiss [24]. An intravenous ingestion of heroin leading to observation of pulmonary edema, brain edema and fluid cadaveric blood along with a “fatal” morphine concentration is considered to be a linear dying type. A death of a patient suffering from prostatic cancer with metastasis and cachexia receiving a high morphine dose with respiratory depression is classified as converging dying type [21]. Thus, in the first case a drug overdose is considered as cause of death, while in the latter case the toxicological influence was contributory. In both cases, however, similar postmortem morphine concentrations would be conceivable. Moreover, these examples clarify that without awareness of death circumstances and morphological findings, the interpretation of postmortem concentrations cannot be conclusive without daring a misinterpretation. Comparable casuistries are imaginable for findings of NPS as well.

In general, interpreting postmortem drug levels requires consideration of several possibilities influencing or altering corresponding concentrations. Measured postmortem concentrations do not necessarily represent those concentrations that were present at the time of death. Chemical instability, circumstances of death (e.g. resuscitation), drug metabolism by endogenous or microbial enzymes, site and time of sampling by means of postmortem redistribution of drugs including passive drug release from gastrointestinal tract, liver, lungs and myocardium as well as cell autolysis and putrefaction, even the position of the body during transport, the method of sample collection and the preservation of the sample can have considerable impact on concentrations [16–18,20,25–28].

Site- and time-dependent drug concentrations (summarized as postmortem redistribution) were tried to be characterized by different approaches. A concentration ratio of central to peripheral sample (e.g. cardiac blood vs. femoral blood) is used for the estimation of a substance’s potential for postmortem redistribution [18,29]. Also a liver to peripheral blood ratio was proposed as a marker of postmortem redistribution [18,30]. A volume of distribution >3 L/kg was supposed to be an indicator for redistribution although this relation may not be the case for every drug [18]. Moreover, basic lipophilic drugs were described to be prone to postmortem redistribution [31]. The time between drug exposure and death as thus different states of drug distribution (e.g. state of equilibrium), however, can result in varying opportunities for postmortem redistribution as diffusion depends on concentration gradient [18,32]. Therefore, an inference regarding a possible postmortem redistribution should not be made alone on the basis of drug concentration ratios between peripheral and central blood. In addition, it should always be considered that both central and peripheral blood concentrations can be elevated by postmortem redistribution and do not inevitably reflect perimortem drug blood concentration [32]. However, peripheral blood like femoral blood is expected to be less affected by postmortem redistribution than central blood [20].

For NPS, however, volume of distribution is sometimes not known and drug distribution (concentrations in body fluids and tissues) were only determined in single cases. Thus, a general prediction of propensity to undergo postmortem redistribution

Table 2
Death cases involving novel opioids.

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
3-methylfentanyl	male, 30 years old	Blood	0.4 μg/L (cis)	Blood: Hydroxyzine: 0.7 mg/L Fluoxetine: 0.4 mg/L Clozapine: 0.2 mg/L Amphetamine: 0.32 μg/L Urine: Amphetamine: positive Cannabinoids: positive Clozapine: positive Fluoxetine: positive Hydroxyzine: positive	Accidental poisoning by 3-methylfentanyl	[60]
3-methylfentanyl	N=8	Whole blood	mean 0.70 ng/mL			[61]
3-methylfentanyl	female, 31 years old	Heart blood	2.6 ng/mL	Naloxone: positive	Acute intoxication by 3-methylfentanyl, accident	[61]
		Femoral blood	1.7 ng/mL	Pseudoephedrine: 620 ng/mL Norpseudoephedrine: 22 ng/mL Diazepam: <20 ng/mL Nordiazepam: <20 ng/mL Cotinine: positive		
		Vitreous humor	0.65 ng/mL			
3-methylfentanyl	female, 41 years old	Blood	0.3 μg/L (cis)	Blood: Ethanol: 0.77 g/L Chloroquine: 0.4 mg/L Amphetamine: 0.65 mg/L Urine: Ethanol: 1.3 g/L Amphetamine: positive Chloroquine: positive Morphine: positive Phenylpropanolamine: positive Hair: Amphetamine: positive Opiates: positive	Combined accidental poisoning with alcohol and drugs	[60]
3-methylfentanyl	male, 35 years old	Blood	0.9 μg/L (cis)	Blood: Diazepam: 0.1 mg/L Desmethyldiazepam: 0.3 mg/L Morphine: 0.03 mg/L Urine: Codeine: positive 6-monoacetylmorphine: positive Morphine: positive	Accidental poisoning by 3-methylfentanyl and heroin	[60]
4-fluorobutyrfentanyl	male, 26 years old	Blood	91 ng/mL			[62] (abstract only)
		Urine	200 ng/mL			
		Liver	902 ng/g			
		Kidney	411 ng/g			
4-fluorobutyrfentanyl	female, 25 years old	Blood	112 ng/mL			[62] (abstract only)
		Urine	414 ng/mL			
		Liver	136 ng/g			
		Kidney	197 ng/g			

α-Methylfentanyl	male, 28 years old	Liver	78 ng/g	Despropionylmethylfentanyl: 5.7 ng/g		[63]
		Blood	3.1 ng/g	Despropionylmethylfentanyl: 3.8 ng/mL		
		Bile	6.4 ng/mL	Despropionylmethylfentanyl: 12.7 ng/mL		
Acetylfentanyl	male, 24 years old	Peripheral blood	260 ng/mL	–	Acute acetyl fentanyl intoxication; accident	[64]
		Central blood	250 ng/mL			
		Liver	1000 ng/kg			
		Vitreous humor	240 ng/mL			
		Urine	2600 ng/mL			
Acetylfentanyl	male, 44 years old	Peripheral blood	38 ng/mL	Butyrfentanyl: 58 ng/mL (see Table 2) Benzoylecgonine: 0.08 mg/L Levamisole: positive	Acute Butyrfentanyl, acetylfentanyl and cocaine intoxication; accident	[65]
		Central blood	32 ng/mL	Butyrfentanyl: 97 ng/mL (see Table 2)		
		Liver	110 ng/g	Butyrfentanyl: 320 ng/g (see Table 2)		
		Vitreous humor	38 ng/mL	Butyrfentanyl: 40 ng/mL (see Table 2)		
		Urine	540 ng/mL	Butyrfentanyl: 670 ng/mL (see Table 2)		
		Gastric	<70 mg	Butyrfentanyl: 170 mg (see Table 2)		
Acetylfentanyl	male, 32 years old	Femoral blood	0.65 ng/mL	THC: 9.6 ng/mL THC-COOH: 13 ng/mL Diphenhydramine: 140 ng/mL Furanylfentanyl: 12.9 ng/mL (see Table 2) Naloxone: positive	Acute intoxication of combined effects of acetyl fentanyl and diphenhydramine	[66]
Acetylfentanyl	male, 28 years old	Subclavian blood	235 ng/mL	Ibuprofen: 3.3 mg/L Tadalafil: 79 ng/mL	Acetyl fentanyl intoxication; accident	[67]
		Liver	2400 ng/g			
		Vitreous fluid	131 ng/mL			
		Urine	234 ng/mL	Acetylnorfentanyl: positive 4-Anilino-N-phenethyl-4-piperidine: positive Testosterone: 34.7 ng/mL Epitestosterone: 2.5 ng/mL Oxandrolone: positive		
Acetylfentanyl	male, 46 years old	Peripheral blood	9 ng/mL	Acetylnorfentanyl: 2 ng/mL Morphine (free): 30 ng/mL Morphine (total): 60 ng/mL 6-acetylmorphine: positive Fentanyl: 21 ng/mL Norfentanyl: 3 ng/mL Cocaine: 70 ng/mL Benzoylecgonine: 970 ng/mL	Intoxication by heroin, fentanyl, acetylfentanyl and cocaine; accident	[68,69]
		Heart blood	26 ng/mL	Fentanyl, Norfentanyl, Acetylnorfentanyl were also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Vitreous humor	31 ng/mL			
		Brain	80 ng/g			
		Liver	180 ng/g			
		Bile	140 ng/mL			
		Urine	980 ng/mL			
Acetylfentanyl	male, 39 years old	Peripheral blood	12 ng/mL	Acetylnorfentanyl: 1 ng/mL Morphine (free): negative Morphine (total): 20 ng/mL Fentanyl: 15 ng/mL Norfentanyl: 3 ng/mL	Intoxication by heroin, fentanyl and acetylfentanyl; accident	[68,69]
		Heart blood	6 ng/mL	Fentanyl, Norfentanyl, Acetylnorfentanyl were also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Vitreous humor	1 ng/mL	6-acetylmorphine: positive		
		Brain	37 ng/g			
		Liver	29 ng/g			
		Bile	23 ng/mL			
		Urine	3 ng/mL	6-acetylmorphine: positive		

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Acetylfentanyl	male, 41 years old	Peripheral blood	6 ng/mL	Acetylnorfentanyl: 1 ng/mL Morphine (free): <20 ng/mL Morphine (total): <20 ng/mL 6-acetylmorphine: positive Alprazolam: 30 ng/mL Fentanyl: 19 ng/mL Norfentanyl: 8 ng/mL	Intoxication by heroin, fentanyl, acetylfentanyl and alprazolam; accident	[68,69]
		Heart blood	2 ng/mL	Fentanyl, Norfentanyl, Acetylnorfentanyl were also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Vitreous humor	4 ng/mL			
		Brain	21 ng/g			
		Liver	36 ng/g			
		Bile	22 ng/mL			
		Urine	15 ng/mL			
Acetylfentanyl	male, 55 years old	Peripheral blood	310 ng/mL	Acetylnorfentanyl: 63 ng/mL	Intoxication by acetylfentanyl and oxycodone; accident	[68,69]
		Heart blood	700 ng/mL	Admission blood (person concerned died next day): Oxycodone: 80 ng/mL Oxymorphone (total): 20 ng/mL Alprazolam: <20 ng/mL		
		Vitreous humor	290 ng/mL	Acetylnorfentanyl was also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Brain	1100 ng/g			
		Liver	690 ng/g			
		Bile	540 ng/mL			
		Urine	6200 ng/mL			
Acetylfentanyl	female, 26 years old	Peripheral blood	400 ng/mL	Acetylnorfentanyl: 3 ng/mL Morphine (free): 30 ng/mL Morphine (total): 70 ng/mL	Intoxication by acetylfentanyl and morphine; accident	[68,69]
		Heart blood	400 ng/mL	Acetylnorfentanyl was also detected in heart blood, vitreous humor, brain, liver and bile.		
		Vitreous humor	100 ng/mL			
		Brain	1700 ng/g			
		Liver	1800 ng/g			
		Bile	100 ng/mL			
Acetylfentanyl	male, 30 years old	Peripheral blood	560 ng/mL	Acetylnorfentanyl: 2 ng/mL Alprazolam: 20 ng/mL	Intoxication by acetylfentanyl and alprazolam; accident	[68,69]
		Heart blood	980 ng/mL	Acetylnorfentanyl was also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Vitreous humor	300 ng/mL			
		Brain	1100 ng/g			
		Liver	1200 ng/g			
		Bile	800 ng/mL			
		Urine	130 ng/mL			
Acetylfentanyl	male, 28 years old	Peripheral blood	600 ng/mL	Acetylnorfentanyl; 36 ng/mL Alprazolam: 230 ng/mL	Intoxication by acetylfentanyl and alprazolam; accident	[68,69]
		Heart blood	670 ng/mL	Acetylnorfentanyl was also detected in heart blood, vitreous humor, brain, liver, bile and urine.		
		Vitreous humor	900 ng/mL			
		Brain	1400 ng/g			
		Liver	1900 ng/g			
		Bile	4800 ng/mL			
		Urine	16000 ng/mL			

Acetylfentanyl	female, 45 years old	Peripheral blood	21 ng/mL	Butyrfentanyl: 3.7 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL Alprazolam: 40 ng/mL Ethanol: 1.1 g/L	Intoxication by the combined effects of butyrfentanyl, acetylfentanyl, alprazolam and ethanol; accident	[70]
		Heart blood	95 ng/mL	Butyrfentanyl: 9.2 ng/mL (see Table 2) Acetylnorfentanyl: 1.2 ng/mL		
		Vitreous humor	68 ng/mL	Butyrfentanyl: 9.8 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL Ethanol: 1.2 g/L		
		Gastric contents	28000 ng/mL	Butyrfentanyl: 4000 ng/mL (see Table 2) Acetylnorfentanyl: 8.9 ng/mL		
		Brain	200 ng/g	Butyrfentanyl: 63 ng/g (see Table 2) Acetylnorfentanyl: <4 ng/g		
		Liver	160 ng/g	Butyrfentanyl: 39 ng/g (see Table 2) Acetylnorfentanyl: <4 ng/g		
		Bile	330 ng/mL	Butyrfentanyl: 49 ng/mL (see Table 2) Acetylnorfentanyl: 4 ng/mL		
		Urine	8 ng/mL	Butyrfentanyl: 2 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL		
Acetylfentanyl	male	Femoral blood	153 ng/mL	Femoral blood: 4-methoxy PV8: 389 ng/mL (see Table 3) Unknown matrix: 7-aminonitrazepam: 0.20 μg/mL Phenobarbital: 7.70 μg/mL Methylphenidate: 0.03 μg/mL Chlorpromazine: positive Risperidone: positive	Acute poisoning by "bath salts" containing acetyl fentanyl and 4-methoxy PV8	[71]
		Heart blood	239 ng/mL	4-methoxy PV8: 960 ng/mL (see Table 3)		
		Urine	240 ng/mL	4-methoxy PV8: 245 ng/mL (see Table 3)		
		Gastric contents	880 ng/mL	4-methoxy PV8: 500 ng/mL (see Table 3)		
Acetylfentanyl	male, 34 years old	Blood	270 ng/mL	Gastric contents and urine: Acetylfentanyl: positive	Lung edema due to acetyl fentanyl intoxication; accident	[72]
Acetylfentanyl	male, 34 years old	Femoral blood	180 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 42 years old	Femoral blood	240 ng/mL	Fentanyl: 3.5 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 32 years old	Heart blood	1000 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 27 years old	Heart blood	8.7 ng/mL	Femoral blood: Fentanyl: 2.2 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 32 years old	Hospital blood	520 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 37 years old	Subclavian blood	2.6 ng/mL	Heart blood Fentanyl: 60.9 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 57 years old	Subclavian blood	31 ng/mL	Heart blood: Fentanyl: 46.6 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 54 years old	Femoral blood	11 ng/mL	Fentanyl: 8.6 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 24 years old	Femoral blood	12 ng/mL	Fentanyl: 7.3 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 50 years old	Femoral blood	7.6 ng/mL	Fentanyl: 5.4 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 57 years old	Heart blood	2100 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 34 years old	Femoral blood	17 ng/mL	Fentanyl: 9.4 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 36 years old	Subclavian blood	220 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 26 years old	Heart blood	37 ng/mL	Fentanyl: 6.6 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 23 years old	Femoral blood	95 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Acetylfentanyl	male, 35 years old	Heart blood	10 ng/mL	Femoral blood: Fentanyl: 8.5 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 23 years old	Femoral blood	2.6 ng/mL	Fentanyl: 8.1 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 21 years old	Femoral blood	8.2 ng/mL	Fentanyl: 8.2 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 24 years old	Femoral blood	4.8 ng/mL	Fentanyl: 8.4 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 26 years old	Femoral blood	1.9 ng/mL	Fentanyl: 3.4 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 43 years old	Heart blood	1.4 ng/mL	Fentanyl: 74.3 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 36 years old	Femoral blood	9.4 ng/mL	Fentanyl: 8.2 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 30 years old	Femoral blood	170 ng/mL	Possibly further substances	Acetylfentanyl toxicity; accident	[73]
Acetylfentanyl	male, 39 years old	Subclavian blood	1.6 ng/mL	Fentanyl: 8.3 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 64 years old	Heart blood	170 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 24 years old	Femoral blood	16 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 30 years old	Heart blood	5.2 ng/mL	Femoral blood: Fentanyl: 11.8 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 56 years old	Chest blood	240 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 26 years old	Heart blood	15 ng/mL	Fentanyl: 53.5 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 56 years old	Heart blood	1.7 ng/mL	Fentanyl: 7.7 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 20 years old	Femoral blood	78 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 27 years old	Heart blood	1300 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 32 years old	Subclavian blood	2.7 ng/mL	Femoral blood: Fentanyl: 14.2 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 26 years old	Heart blood	300 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 41 years old	Heart blood	110 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 42 years old	Heart blood	0.43 ng/mL	Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 21 years old	Blood	4.1 ng/mL	Fentanyl: 10 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 53 years old	Blood	5.3 ng/mL	Fentanyl: 13 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 30 years old	Peripheral blood	0.45 ng/mL	Fentanyl: 16 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 26 years old	Blood	2.1 ng/mL	Fentanyl: 8.6 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	female, 38 years old	Peripheral blood	0.13 ng/mL	Fentanyl: 0.24 ng/mL Possibly further substances	Multiple drug toxicity; accident	[73]
Acetylfentanyl	male, 20 years old	Heart blood	285 ng/mL	Fluoxetine: positive Methoxetamine: positive (see Table 3)	Accidental death from acetyl fentanyl toxicity	[73]
		Femoral blood	192 ng/mL			
		Liver	1100 ng/g			
		Brain	620 ng/g			
		Urine	3420 ng/mL			
Acetylfentanyl	female, 50 years old	Heart blood	210 ng/mL	Venlafaxine: positive Chlordiazepoxide: positive Nordiazepam: positive	Accidental death from acetyl fentanyl toxicity	[74]
		Femoral blood	255 ng/mL	Venlafaxine: 2.0 μg/mL		
		Urine	2720 ng/mL			
		Vitreous humor	140 ng/mL			

Acetylfentanyl	male, 24 years old	Blood	approx. 400 ng/mL			[75] (abstract only)
		Liver	approx. 3000 ng/g			
Acetylfentanyl	N=8	Whole blood	mean 0.15 ng/mL			[61]
Acetylfentanyl	male, 54 years old	Heart blood	7.2 ng/mL	Fentanyl: 35 ng/mL Norfentanyl: 0.53 ng/mL THC: 5.9 ng/mL 11-OH-THC: 1.1 ng/mL THC-COOH: 42 ng/mL	Acute intoxication due to the combined effects of heroin, fentanyl and acetylfentanyl, accident	[61]
		Femoral blood	2.2 ng/mL	Fentanyl: 7.3 ng/mL Norfentanyl: 0.26 ng/mL Morphine: 176 ng/mL Codeine: <10 ng/mL 6-acetylmorphine: 6 ng/mL		
		Vitreous humor	1.3 ng/mL	Fentanyl: 5.1 ng/mL Norfentanyl: not detected		
Acetylfentanyl	male, 36 years old	Peripheral blood	0.31 ng/mL	Blood: Cyclopropylfentanyl: 6.1 ng/mL (see Table 2) para-Fluoroisobutyrylfentanyl (FIBF): 7.5 ng/mL (see Table 2) Cocaine: 170 ng/mL Benzoylecgonine: 240 ng/mL Morphine: 12 ng/mL Diphenhydramine: 120 ng/mL Fentanyl: 3.6 ng/mL Urine: 6-monoacetylmorphine: 15 ng/mL	Accidental drug overdose	[76]
Acrylfentanyl	male, 21 years old	Femoral blood	0.06 ng/g	Blood: Amphetamines: 0.18 μg/g 7-aminoclonazepam: 0.03 μg/g THC: 0.0056 μg/g Urine: Ethanol: 0.14 ‰	Overdose of narcotics	[77]
Acrylfentanyl	male, 24 years old	Femoral blood	0.67 ng/g	THC: 0.0006 μg/g	Poisoning with acrylfentanyl	[77]
Acrylfentanyl	male, 30 years old	Femoral blood	1.2 ng/g	Diazepam: 0.05 μg/g Zopiclone: 0.02 μg/g Nordazepam: 0.07 μg/g Gabapentin: 7.2 μg/g MO-CHMINACA: positive	Poisoning with acrylfentanyl	[77]
Acrylfentanyl	male, 22 years old	Femoral blood	4.1 ng/g	Mirtazapine: 0.42 μg/g Desmethylmirtazapine: 0.04 μg/g Citalopram: 0.12 μg/g Sertraline: 0.08 μg/g Desmethylsertraline: 0.07 μg/g Ethanol: 0.34 ‰ 4-MeO-αPOP: positive EC-018: positive E-2201: positive MO-CHMINACA: positive	Overdose of narcotics	[77]
Acrylfentanyl	female, 28 years old	Femoral blood	0.14 ng/g	Pregabalin: 29 μg/g 7-aminonitrazepam: 0.005 μg/g Diazepam: 0.28 μg/g Zopiclone: 0.11 μg/g Alimemazine: 0.09 μg/g Nordazepam: 0.47 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 27 years old	Femoral blood	0.1 ng/g	Etoricoxib: 0.26 μg/g Paracetamol: 15 μg/g	Poisoning with acrylfentanyl	[77]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Acrylfentanyl	male, 25 years old	Femoral blood	0.05 ng/g	Promethazine: 0.21 μg/g Desmetylpromethazine: 0.08 μg/g Alimemazine: 0.2 μg/g Dihydropropiomazine: 0.04 μg/g 4-Cl-α-PVP: positive	Overdose of narcotics	[77]
Acrylfentanyl	male, 21 years old	Femoral blood	0.16 ng/g	Paracetamol: 11 μg/g Ephedrine: 0.21 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 25 years old	Femoral blood	0.11 ng/g	Blood: Bupropion: 0.09 μg/g Mirtazapine: 0.06 μg/g Desmethylmirtazapine: 0.02 μg/g Urine: Acetone: 0.43 ‰	Overdose of narcotics	[77]
Acrylfentanyl	male, 24 years old	Femoral blood	3.9 ng/g	Quetiapine: 0.04 μg/g Diazepam: 0.15 μg/g Nordazepam: 0.19 μg/g Oxycodone: 0.01 μg/g Benzoylecgonine: 0.32 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	female, 49 years old	Femoral blood	0.68 ng/g	Blood: Venlafaxine: 1.3 μg/g O-desmethylvenlafaxine: 1.5 μg/g Dihydropropiomazine: 0.16 μg/g Diazepam: 0.05 μg/g Nordazepam: 0,15 μg/g Zolpidem: 0.06 μg/g Aqueous humor: Glucose: 2.9 mmol/L	Drug poisoning with multiple substances	[77]
Acrylfentanyl	male, 33 years old	Femoral blood	1.7 ng/g	Mirtazapine: 0.39 μg/g Desmethylmirtazapine: 0.03 μg/g Citalopram: 0.19 μg/g Desmethylcitalopram: 0.06 μg/g Ethanol: 1.16 ‰	Poisoning with acrylfentanyl	[77]
Acrylfentanyl	male, 25 years old	Femoral blood	0.02 ng/g		Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 48 years old	Femoral blood	0.31 ng/g	Blood: Mirtazapine: 0.09 μg/g Desmethylmirtazapine: 0.03 μg/g Citalopram: 0.34 μg/g O-desmethylcitalopram: 0.07 μg/g Pregabalin: 7.9 μg/g Methylphenidate: 0.004 μg/g Ritalinic acid: 0.18 μg/g N-ethylnorhexedrone: positive Ethanol: 0.23 ‰ Urine: Ethanol: 0.23 ‰ Hair: Diazepam: positive Zopiclone: positive	Overdose of narcotics	[77]
Acrylfentanyl	male, 22 years old	Femoral blood	0.78 ng/g	Blood: 7-aminoclonazepam: 0.1 μg/g Nordazepam: 0.03 μg/g Urine: Ethanol: 0.11 ‰ Hair: Diazepam: positive 7-aminoclonazepam: positive Zolpidem: positive Tramadol: positive	Overdose of narcotics	[77]

Acrylfentanyl	male, 34 years old	Femoral blood	0.23 ng/g	Mirtazapine: 0.05 μg/g Desmethylmirtazapine: 0.03 μg/g Gabapentin: 8.2 μg/g THC: 0.0038 μg/g 4Cl-isobutylfentanyl: 0.0081 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 31 years old	Femoral blood	0.04 ng/g	Blood: N-ethylnorhexedrone: positive Aqueous humor: Glucose: 1.8 mmol/L	Overdose of acrylfentanyl	[77]
Acrylfentanyl	male, 18 years old	Femoral blood	0.07 ng/g	Olanzapine: 0.08 μg/g Fluoxetine: 0.97 μg/g Norfluoxetine: 0.60 μg/g Lamotrigine: 3.0 μg/g	Overdose of acrylfentanyl	[77]
Acrylfentanyl	male, 49 years old	Femoral blood	5.0 ng/g	Blood: Oxycodone: 83 μg/g Hydrocodone: 0.046 μg/g Mirtazapine: 0.09 μg/g Desmethylmirtazapine: 0.04 μg/g O-desmethylvenlafaxine: 0.07 μg/g Ethanol: 2.88 ‰ Urine: Ethanol: 1.99 ‰	Overdose of narcotics	[77]
Acrylfentanyl	male, 36 years old	Femoral blood	2.1 ng/g	Blood: Quetiapine: 0.16 μg/g Lithium: 0.027 μg/g Ethanol: 0.27 ‰ Urine: Ethanol: 0.52 ‰	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 31 years old	Femoral blood	0.22 ng/g	Alprazolam: 0.02 μg/g Pregabalin: 5.3 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 36 years old	Femoral blood	0.18 ng/g	Levomepromazine: 0.07 μg/g Zopiclone: 0.09 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 21 years old	Femoral blood	0.03 ng/g	7-aminoclonazepam: 0.07 μg/g Alprazolam: 0.02 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	female, 45 years old	Femoral blood	2.9 ng/g	Bupropion: 0.22 μg/g Hydroxybupropion: 5 μg/g Quetiapine: 0.13 μg/g Fluoxetine: 1.7 μg/g Norfluoxetine: 1.6 μg/g Dihydropropriomazine: 0.10 μg/g Diazepam: 0.09 μg/g Nordazepam: 0.12 μg/g Zopiclone: 0.08 μg/g	Overdose of narcotics (acrylfentanyl and antidepressants)	[77]
Acrylfentanyl	female, 49 years old	Femoral blood	0.05 ng/g	9-hydroxyrisperidone: 0.0043 μg/g Alprazolam: 0.008 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 53 years old	Femoral blood	0.06 ng/g	7-aminoclonazepam: 0.14 μg/g Pregabalin: 3.0 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 44 years old	Femoral blood	0.04 ng/g	Blood: Amlodipine: 0.04 μg/g Ethanol: 1.41 ‰ Urine: Ethanol: 1.34 ‰	Alcohol and intoxication with acrylfentanyl	[77]
Acrylfentanyl	female, 36 years old	Femoral blood	0.52 ng/g	Fluoxetine: 0.23 μg/g Norfluoxetine: 0.3 μg/g 7-aminoclonazepam: 0.01 μg/g Diazepam: 0.03 μg/g Nordazepam: 0.15 μg/g Ethanol: 0.12 ‰	Overdose of narcotics (acrylfentanyl)	[77]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Acrylfentanyl	male, 22 years old	Femoral blood	0.52 ng/g	Blood: 7-aminoclonazepam: 0.03 μg/g Ethanol: 0.12 ‰ Urine: Ethanol: 0.19 ‰	Drug overdose	[77]
Acrylfentanyl	male, 33 years old	Femoral blood	0.1 ng/g	Blood: Alprazolam: 0.008 μg/g Diazepam: 0.22 μg/g Nordazepam: 0.41 μg/g Oxazepam: 0.03 μg/g Urine: Ethanol: 0.12 ‰	Intoxication with acrylfentanyl	[77]
Acrylfentanyl	male, 28 years old	Femoral blood	0.19 ng/g	Propranolol: 0.02 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 34 years old	Femoral blood	0.01 ng/g	Blood: Ethanol: 0.46 ‰ Urine: Ethanol: 0.6 ‰	Overdose of narcotics	[77]
Acrylfentanyl	male, 43 years old	Femoral blood	0.03 ng/g	Sertraline: 0.14 μg/g Desmethylsertraline: 0.17 μg/g Quetiapine: 0.05 μg/g Pregabalin: 2 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 37 years old	Femoral blood	0.3 ng/g	Amphetamine: 0.11 μg/g Pregabalin: 3.1 μg/g	Overdose of narcotics (acrylfentanyl)	[77]
Acrylfentanyl	male, 29 years old	Femoral blood	0.6 ng/g	Blood: Alimemazine: 0.2 μg/g Mirtazapine: 0.12 μg/g Desmethylmirtazapine: 0.05 μg/g Sertraline: 0.78 μg/g Desmethylsertraline: 0.88 μg/g Hydroxyzine: 0.12 μg/g Ethanol: 0.54 ‰ Urine: Ethanol: 0.2 ‰	Overdose of narcotics	[77]
Acrylfentanyl	male, 31 years old	Femoral blood	0.19 ng/g	Blood: Alimemazine: 0.3 μg/g Desmethylalimemazine: 0.1 μg/g Oxycodone: 0.017 μg/g Gabapentin: 0.79 μg/g Duloxetine: 0.22 μg/g 4F-isobutyrfentanyl / para-Fluoroisobutyrylfentanyl (FIBF): 26 ng/g (see Table 2) Ethanol: 1.91 ‰ Urine: Ethanol: 2.47 ‰	Intoxication with alcohol and several drugs: benzodiazepine, acrylfentanyl	[77]
Acrylfentanyl	female, 40 years old	Femoral blood	0.01 ng/g	Blood: Desmethylalimemazine: 0.2 μg/g Diazepam: 0.03 μg/g Nordazepam: 0.14 μg/g Oxazepam: 0.1 μg/g Zolpidem: 0.37 μg/g Atomoxetine: 0.4 μg/g Vortioxetine: 0.40 μg/g Ethanol: 1,78 ‰ Urine: Ethanol: 2,02 ‰	Overdose of narcotics (acrylfentanyl)	[77]

Acrylfentanyl	male, 22 years old	Femoral blood	0.26 ng/g	Alprazolam: 0.06 μg/g Amphetamine: 0.03 μg/g MDMA: 0.08 μg/g THC: 0.0008 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 24 years old	Femoral blood	0.02 ng/g	Amphetamine: 0.60 μg/g Diazepam: 0.60 μg/g Nordazepam: 0.75 μg/g 7-aminoclonazepam: 0.09 μg/g Oxazepam: 0.1 μg/g Temazepam: 0.07 μg/g Risperidone: 0.0022 μg/g 9-hydroxyrisperidone: 0.0010 μg/g Olanzapine: 0.04 μg/g	Overdose of narcotics	[77]
Acrylfentanyl	male, 32 years old	Femoral blood	2.8 ng/g	Blood: Diazepam: 0.37 μg/g Nordazepam: 0.14 μg/g Ethanol: 0.86 ‰ Urine: Ethanol: 0.96 ‰	Drug overdose (acrylfentanyl)	[77]
Acrylfentanyl	male, 23 years old	Peripheral blood	0.3 ng/mL	Peripheral blood: Ibuprofen: 7.1 μg/mL Nicotine: positive Cotinine: positive Urine: Amphetamine: 1540 ng/mL Methamphetamine: 3467 ng/mL THC-COOH: 22 ng/mL Fentanyl: 0.6 ng/mL Norfentanyl: 1.5 ng/mL	Toxic effects of acrylfentanyl; accident	[78]
Acrylfentanyl	male, 43 years old	Peripheral blood	0.95 ng/mL	Peripheral blood: Free hydrocodone: 11 ng/mL Caffeine: positive Naloxone: positive Urine: Presumptively positive for opiates, fentanyl or metabolites, nicotine. Ethanol: 0.26 g/L Free dihydrocodeine/hydrocodol: 28 ng/mL Free hydrocodone: 1.3 ng/mL Free hydromorphone: 6.0 ng/mL	Toxic effects of acrylfentanyl and hydrocodone; accident	[78]
Acrylfentanyl	male, 26 years old	Peripheral blood	0.32 ng/mL	Peripheral blood: Furanylfentanyl: 0.95 ng/mL (see Table 2) Naloxone: positive Nicotine: positive Cotinine: positive Urine: Morphine: positive Hydromorphone: positive	Acrylfentanyl and furanylfentanyl toxicity; accident	[78]
Acrylfentanyl	male, 53 years old	Femoral blood	0.64 ng/mL	Blood: Methoxyacetylfentanyl: 11.5 ng/mL (see Table 2) Morphine: 13 ng/mL Fentanyl: 2.0 ng/mL Norfentanyl: 0.31 ng/mL Methamphetamine: 23 ng/mL	Acrylfentanyl, methoxyacetylfentanyl, heroin, fentanyl and methamphetamine toxicity	[76]
Acrylfentanyl	male, 35 years old	Femoral blood	2.1 ng/mL	Blood: Methoxyacetylfentanyl: 36.2 ng/mL (see Table 2) Cocaine: 120 ng/mL Benzoylecgonine: 3500 ng/mL	Acute combined drug overdose (acrylfentanyl and cocaine)	[76]
AH-7921	male, 27 or 28 years old	Femoral blood	0.81 μg/g	Gabapentin:10 μg/g	Unintentional overdose; intoxication; accident	[79–81]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
AH-7921	male, 25 or 26 years old	Femoral blood	0.99 μg/g	Amphetamine: 4.7 μg/g Aripiprazole: 0.16 μg/g Dehydroaripiprazole: 0.06 μg/g	Pneumonia caused by aspiration; aspiration caused by intoxication; accident	[79–81]
AH-7921	male, 24 years old	Heart blood	0.03 μg/g	Ethanol: 0.11 g/L Paroxetine: 0.03 μg/g	Intoxication; accident	[79–81]
AH-7921	male, 45 years old	Femoral blood	0.20 μg/g	Alimemazine: 0.08 μg/g Codeine: 0.12 μg/g Diazepam: 0.03 μg/g Nordazepam: 0.09 μg/g Tramadol: 0.64 μg/g O-Desmethyltramadol: 0.04 μg/g Paracetamol: 5 μg/g Pyrazolam: positive	Intoxication; overdose of benzodiazepines and opiates; uncertain	[79–81]
AH-7921	male, 26 years old	Femoral blood	0.30 μg/g	Alprazolam: 0.003 μg/g Hydroxyzine: 0.09 μg/g Promethazine: 0.1 μg/g Desmethylpromethazine: 0.1 μg/g Zopiclone: 0.02 μg/g Paracetamol: 4 μg/g Pyrazolam: positive	Intoxication; uncertain	[79–81]
AH-7921	male, 34 years old	Femoral blood	0.08 μg/g	Blood: Ethanol: 0.17 g/L N-Ethylnorketamine: 0.01 μg/g Hair: Tramadol: positive	Intoxication; uncertain	[79–81]
AH-7921	male, 27 years old	Femoral blood	0.16 μg/g	Amphetamine: 0.04 μg/g	Intoxication; accident	[79–81]
AH-7921	male, 25 years old	Femoral blood	0.35 μg/g	3-methylmethcathinone (3-MMC): positive (see Table 3)	Intoxication; accident	[79–81]
AH-7921		Femoral blood	0.58 μg/mL	Femoral blood: 4-methylethcathinone (4-MEC) (see Table 3) and/or pentedrone (see Table 3) metabolites: positive Urine: 4-methylethcathinone (4-MEC): positive (seeTable 3) Pentedrone: positve (seeTable 3) Mephedrone (4-MMC): positive (seeTable 3) Diphenylpropinol (D2PM): positive Etizolam: positive (seeTable 3) Etaqualone: positive		[79,80,82]
AH-7921		Femoral blood	0.05 μg/mL	Chloroform: positive Ethanol: positive	Found dead with bag over head containing chloroform	[79,80,82]
AH-7921		Femoral blood	4.46 μg/mL	Blood: Doxylamine: positive Mirtazapine: positive Urine: Clobazam: positive Doxylamine: positive Mirtazapine: positive Codeine metabolite: positive		[79,80,82]
AH-7921	male, 23 years old	Peripheral blood	1.3 nmol/mL	2-fluoromethamphetamine (2-FMA): 0.041 nmol/mL (see Table 3) 3-methylmethcathinone (3-MMC): 0.012 nmol/mL (see Table 3) Codeine: 1.4 nmol/mL Paracetamol: 124 nmol/mL		[79,80]

AH-7921	male, 22 years old	Femoral blood	0.43 μg/g	Bupropion: 0.40 μg/g Hydroxybupropion: 0.53 μg/g Diazepam: 0.12 μg/g Nordazepam: 0.17 μg/g Pregabalin: 12 μg/g Mirtazapine: 0.10 μg/g Desmethylmirtazapine: 0.02 μg/g	Intoxication; uncertain	[79–81]
AH-7921	male, 19 years old	Peripheral blood	9.1 μg/mL		Opioid intoxication; accident	[80,83]
		Heart blood	3.9 μg/mL			
		Urine	6.0 μg/mL	4-methyl-a-pyrrolidinohexanophenone (MPHP): 0.10 mg/L Dextromethorphan: positive		
		Liver	26 μg/g			
		Kidney	7.2 μg/g			
		Spleen	8.0 μg/g			
		Heart	5.1 μg/g			
		Lung	21 μg/g			
		Brain	7.7 μg/g			
		Bile	17 μg/mL			
		Stomach contents	120 mg/125 mL			
AH-7921	female, 22 years old	Femoral blood	450 ng/mL	Methadone: positive Diphenhydramine: positive Tetrazepam: positive Methamphetamine: traces Amphetamine: traces Mirtazapine: 43.2 ng/mL	By exclusion of other causes of death, attributed to consumption of an overdose of AH-7921	[46]
		Heart blood	480 ng/mL			
		Liver	530 ng/g			
		Urine	760 ng/mL			
		Vitreous humor	190 ng/mL			
		Pericardial fluid	480 ng/mL			
		Stomach contents	40 μg/mL			
		Hair	Positive in all segments (0-38 cm)	Oxycodone: positive Amphetamine: positive Methamphetamine: positive THC: positive Methadone: positive EDDP: positive Tilidine: positive Nortilidine: positive Doxepin: positive Mirtazapine: positive Diphenhydramine: positive Ketamine: positive Norketamine: positive Hydrocodone: positive Codeine: positive Dihydrocodeine: positive MDMA: positive MDA: positive Tramadol: positive Diazepam: positive Quetiapine: positive Tetrazepam: positive Citalopram: positive Paracetamol: positive		
AH-7921	male	Peripheral blood	0.43 μg/mL	Codeine: 0.42 μg/mL Codeine-6-glucuronide: 0.77 μg/mL Acetaminophen: 19 μg/mL 2-Fluoromethamphetamine (2-FMA): 0.0069 μg/mL (see Table 3) 3-Methylmethcathinone (3-MMC): 0.0021 μg/mL (see Table 3)	Intoxication with AH-7921 in combination with other psychoactive drugs	[84]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
AH-7921	female	Peripheral blood	0.33 μg/mL	Methoxetamine: 64 ng/mL (see Table 3) Etizolam: 0.27 μg/mL (see Table 3) Phenazepam: 1.33 μg/mL 7-aminonitrazepam: 0.043 μg/mL Diazepam: 0.046 μg/mL Nordiazepam: 0.073 μg/mL Oxazepam: 0.018 μg/mL	Intoxication with AH-7921 in combination with several benzodiazepines and methoxetamine	[84]
Butyrfentanyl	male, 44 years old	Peripheral blood	58 ng/mL	Acetyl-Fentanyl: 38 ng/mL (see Table 2) Benzoylecgonine: 0.08 mg/L Levamisole: positive	Acute Butyrfentanyl, acetylfentanyl and cocaine intoxication; accident	[65]
		Central blood	97 ng/mL	Acetylfentanyl: 32 ng/mL (see Table 2)		
		Liver	320 ng/g	Acetylfentanyl: 110 ng/g (see Table 2)		
		Vitreous humor	40 ng/mL	Acetylfentanyl: 38 ng/mL (see Table 2)		
		Urine	670 ng/mL	Acetylfentanyl: 540 ng/mL (see Table 2)		
		Gastric	170 mg	Acetylfentanyl: <70 mg (see Table 2)		
Butyrfentanyl	male, 18 years old	Peripheral blood	26 ng/mL	Blood: Ethanol: 0.30 g/L U-47700: 17 ng/mL (see Table 2) Urine: Carbamazepine: positive Ibuprofen: positive Iminostilbene: positive Oxcarbazepine: positive Butyrfentanyl: suspected Vitreous humor: Ethanol: 0.30 mg/L		[66]
Butyrfentanyl	male, 30 years old	Peripheral blood	0.33 ng/mL	THC: 1.0 ng/mL Tramadol: 75 ng/mL O-Desmethyltramadol: 40 ng/mL Furanylfentanyl: 6.1 ng/mL (see Table 2)		[66]
Butyrfentanyl	female, 53 years old	Peripheral blood	99 ng/mL	–	Fatal intoxication by butyrfentanyl; accident	[70]
		Heart blood	220 ng/mL			
		Vitreous humor	32 ng/mL			
		Gastric contents	590 ng/mL			
		Brain	93 ng/g			
		Liver	41 ng/g			
		Bile	260 ng/mL			
		Urine	64 ng/mL			
Butyrfentanyl	female, 45 years old	Peripheral blood	3.7 ng/mL	Acetylfentanyl: 21 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL Alprazolam: 40 ng/mL Ethanol: 1.1 g/L	Intoxication by the combined effects of butyrfentanyl, acetylfentanyl, alprazolam and ethanol; accident	[70]
		Heart blood	9.2 ng/mL	Acetylfentanyl: 95 ng/mL (see Table 2) Acetylnorfentanyl: 1.2 ng/mL		
		Vitreous humor	9.8 ng/mL	Acetylfentanyl: 68 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL Ethanol: 1.2 g/L		
		Gastric contents	4000 ng/mL	Acetylfentanyl: 28000 ng/mL (see Table 2) Acetylnorfentanyl: 8.9 ng/mL		
		Brain	63 ng/g	Acetylfentanyl: 200 ng/g (see Table 2) Acetylnorfentanyl: <4 ng/g		
		Liver	39 ng/g	Acetylfentanyl: 160 ng/g (see Table 2) Acetylnorfentanyl: <4 ng/g		
		Bile	49 ng/mL	Acetylfentanyl: 330 ng/mL (see Table 2) Acetylnorfentanyl: 4 ng/mL		
		Urine	2 ng/mL	Acetylfentanyl: 8 ng/mL (see Table 2) Acetylnorfentanyl: <1 ng/mL		

Butyrfentanyl	male, 23 years old	Femoral blood		Benzoylecgonine: <LoQ (1.25 ng/mL)	Most probably intoxication with butyrfentanyl	[85]
		(Admission, 9 h after death)	66 ng/mL	Midazolam:<LoQ (11 ng/mL)		
		(Autopsy, 28 h after death)	approx. 145 ng/mL	Hydroxymidazolam: 1.0 ng/mL		
		Heart blood (right ventricle)				
		(Admission, 9 h after death)	39 ng/mL			
		(Autopsy, 28 h after death)	approx. 60 ng/mL			
		Heart blood (left ventricle)				
		(Autopsy, 28 h after death)	approx. 72 ng/mL			
		Lung				
		(Admission, 9 h after death)	3000 ng/g			
		(Autopsy, 28 h after death)	approx. 2100 ng/mL			
		Liver (l. dexter)				
		(Admission, 9 h after death)	57 ng/g			
		(Autopsy, 28 h after death)	approx. 72 ng/g			
		Liver (l. sinister)				
		(Autopsy, 28 h after death)	approx. 87 ng/g			
		Kidney				
		(Admission, 9 h after death)	160 ng/g			
		(Autopsy, 28 h after death)	approx. 188 ng/g			
		Spleen				
		(Admission, 9 h after death)	590 ng/g			
		(Autopsy, 28 h after death)	approx. 478 ng/g			
		Muscle				
		(Admission, 9 h after death)	110 ng/g			
		(Autopsy, 28 h after death)	approx. 145 ng/g			
		Adipose tissue				
		(Admission, 9 h after death)	550 ng/g			
		(Autopsy, 28 h after death)	approx. 797 ng/g			
		Urine				
		(Autopsy, 28 h after death)	1100 ng/mL			
		Gastric contents				
		(Autopsy, 28 h after death)	2000 ng/mL			
		Brain				
		(Autopsy, 28 h after death)	200-340 ng/g			
		Hair		Cocaine: 7600 pg/mg		
		(Autopsy, 28 h after death)	11000 pg/mg	benzoylecgonine: 1200 pg/mg Norcocaine: 160 pg/mg Amphetamine: 240 pg/mg Midazolam: 20 pg/mg α-Hydroxymidazolam: <LOQ Ketamine: 300 pg/mg		
Carfentanil	male, 34 years old	Heart blood	1.3 ng/mL	Heart blood: Furanylfentanyl: 0.34 ng/mL (see Table 2) Fentanyl: 6 ng/mL Morphine (total): <20 ng/mL Hydromorphone (total): <20 ng/mL Vitreous humor: 6-monoacetylmorphine, hydrocodone and hydromorphone: positive Urine: Morphine (total), hydromorphone (total), 6-monoacetylmorphine and hydrocodone: positive Peripheral blood: Fentanyl, morphine (total), hydromorphone (total), 6-monoacetylmorphine and hydrocodone: not detected	Intoxication by the combined effects of heroin, fentanyl, carfentanil and furanylfentanyl; accident	[86]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Carfentanil	male, 25 years old	Heart blood	0.12 ng/mL	Peripheral blood: Cocaine: not detected Benzoylecgonine: 460 ng/mL Vitreous humor: Cocaine: 40 ng/mL Benzoylecgonine: 510 ng/mL	Intoxication by carfentanil; accident	[86]
Carfentanil	male, 39 years old	Whole blood	742 pg/mL	Fentanyl: 1.3 ng/mL Norfentanyl: <0.1 ng/mL Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Ethanol: 0.15 g/L Morphine (free): 81 ng/mL Morphine (total): 101 ng/mL Noscapine metabolites and papaverine metabolites: positive Diazepam: 257 ng/mL Nordiazepam: 192 ng/mL Temazepam: 15 ng/mL Oxazepam: 22 ng/mL Benzoylecgonine: 25 ng/mL Codeine: 6 ng/mL Paracetamol: 5.6 μg/mL Methadone: <5 ng/mL EDDP: <5 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	379 pg/mL	4F-butyrfentanyl: positive Ethanol: 0.25 g/L 6-monoacetylmorphine: positive		
Carfentanil	male, 47 years old	Whole blood	408 pg/mL	Fentanyl: 1.0 ng/mL Norfentanyl: <0.1 ng/mL Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Morphine (free): 79 ng/mL Morphine (total): 93 ng/mL Methadone: 750 ng/mL EDDP: 65 ng/mL Diazepam: 87 ng/mL Nordiazepam: 76 ng/mL Oxazepam: <5 ng/mL Temazepam: <5 ng/mL Pregabalin: 0.9 mg/L Codeine: 24 ng/mL Cocaine: 44 ng/mL Benzoylecgonine: 233 ng/mL Quetiapine: 347 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	12.1 ng/mL	Carfentanil metabolites: positive Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive 6-monoacetylmorphine: positive		
Carfentanil	male, 32 years old	Whole blood	204 pg/mL	Morphine (free): 13 ng/mL Morphine (total): 36 ng/mL Noscapine metabolites and papaverine metabolites: positive Codeine: <5 ng/mL Cocaine: 23 ng/mL Benzoylecgonine: 1307 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	2097 pg/mL	Carfentanil metabolites: positive 6-monoacetylmorphine: positive		

Carfentanil	male, 41 years old	Whole blood	1555 pg/mL	Fentanyl: 3.1 ng/mL Norfentanyl: <0.1 ng/mL Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Morphine (free): 138 ng/mL Morphine (total): 145 ng/mL Methadone: 2283 ng/mL EDDP: 134 ng/mL Diazepam: 134 ng/mL Nordiazepam: 321 ng/mL Oxazepam: 14 ng/mL Temazepam: 12 ng/mL Pregabalin: 35.3 ng/mL Paracetamol: 6.2 mg/L Codeine: 12 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	219 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive		
Carfentanil	male, 44 years old	Whole blood	230 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Morphine (free): 18 ng/mL Morphine (total): 21 ng/mL Noscapine metabolites and papaverine metabolites detected Mirtazapine: 15 ng/mL Diazepam: 68 ng/mL Nordiazepam: 29 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	175 pg/mL	Butyrfentanyl: positive (see Table 2) Furanylfentanyl: positive (see Table 2)		
Carfentanil	male, 47 years old	Whole blood	301 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Morphine (free): 33 ng/mL Morphine (total): 47 ng/mL Noscapine metabolites and papaverine metabolites: positive Nordiazepam: 10 ng/mL Olanzapine: 14 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	male, 39 years old	Antemortem serum	28 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Despropionylfentanyl: positive Morphine (free): 12 ng/mL Morphine (total): 111 ng/mL Noscapine metabolites: positive Methadone: 16 ng/mL Codeine: 5 ng/mL Cocaine: 7 ng/mL Benzoylecgonine: 1587 ng/mL Diazepam: 357 ng/mL Nordiazepam: 251 ng/mL Temazepam: 9 ng/mL Oxazepam: 5 ng/mL Valproate: 5.9 mg/L	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Carfentanil	male, 40 years old	Whole blood	180 pg/mL	Fentanyl: 1.0 ng/mL Norfentanyl: <0.1 ng/mL Butyrfentanyl: positive (see Table 2) Morphine (free): 316 ng/mL Morphine (total): 479 ng/mL 6-monoacetylmorphine: positive Noscapine metabolites and papaverine metabolites: positive Paracetamol: 7.6 mg/L Diazepam: 28 ng/mL Dihydrocodeine: 364 ng/mL Gabapentin: 48.8 ng/mL Mirtazapine: 174 ng/mL Codeine: 18 ng/mL Cocaine: 19 ng/mL Benzoylecgonine: 1659 ng/mL Cocaethylene: <5 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	338 pg/mL	Butyrfentanyl: positive (see Table 2) Ethanol: 0.14 g/L 6-monoacetylmorphine: positive		
Carfentanil	female, 28 years old	Blood	536 pg/mL	Fentanyl: 1.7 ng/mL Norfentanyl: 0.3 ng/mL Butyrylfentanyl: positive (see Table 2) 4F-butyrylfentanyl: positive Ethanol: 2.45 g/L Morphine (free): 49 ng/mL Morphine (total): 53 ng/mL Noscapine metabolites: positive Diazepam: <5 ng/mL Nordiazepam: 16 ng/mL Mirtazapine: 151 ng/mL Methadone: 314 ng/mL EDDP: 29 ng/mL Tramadol: <5 ng/mL Sertraline: 35 ng/mL Codeine: 5 ng/mL Cocaine: 96 ng/mL Benzoylecgonine: 863 ng/mL Cocaethylene: 140 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	male, 31 years old	Whole blood	177 pg/mL	Morphine (free): 5 ng/mL Morphine (total): 5 ng/mL Alprazolam: 77 ng/mL Diazepam: 6 ng/mL Nordiazepam: 28 ng/mL Sertraline: 154 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	30 pg/mL			
Carfentanil	male, 25 years old	Whole blood	582 pg/mL	Carfentanil metabolites: positive Fentanyl: 1.8 ng/mL Norfentanyl: 0.3 ng/mL Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Furanylfentanyl: positive (see Table 2) Morphine (free): 119 ng/mL Morphine (total): 137 ng/mL Codeine: 14 ng/mL Paracetamol: 14.3 mg/L Diazepam: 433 ng/mL Nordiazepam: 1396 ng/mL Temazepam: 50 ng/mL Oxazepam: 88 ng/mL THC 1.2 ng/mL THC-COOH: 15.4 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]

		Urine	553 pg/mL	Carfentanil metabolites: positive Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive 6-monoacetylmorphine: positive		
Carfentanil	male, 31 years old	Whole blood	479 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Ethanol: 0.1 g/L Morphine (free): 16 ng/mL Morphine (total): 17 ng/mL Diazepam: 558 ng/mL Nordiazepam: 458 ng/mL Temazepam: 16 ng/mL Oxazepam: <5 ng/mL Methadone: 498 ng/mL EDDP: 50 ng/mL Mirtazapine: 128 ng/mL 5F-ADB: positive (see Table 1) Benzoylecgonine: 19 ng/mL Pregabalin: 4.0 mg/L	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	144 pg/mL	Carfentanil metabolites: positive Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Ethanol: 0.22 g/L		
Carfentanil	male, 30 years old	Whole blood	136 pg/mL	Morphine: <LoD Norfluoxetine: 33 ng/mL THC: <2 ng/mL THC-COOH: 9.4 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	4404 pg/mL	Carfentanil metabolites: positive Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive		
Carfentanil	male, 41 years old	Whole blood	175 pg/mL	Morphine (free): 155 ng/mL Morphine (total): 200 ng/mL 6-monoacetylmorphine: positive Noscapine metabolites: positive Methadone: 24 ng/mL Gabapentin: 28.9 mg/L Codeine: 8 ng/mL Diazepam: 6 ng/mL Nordiazepam: 11 ng/mL Cocaine: 337 ng/mL Benzoylecgonine: 1329 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	387 pg/mL	Carfentanil metabolites: positive 6-monoacetylmorphine: positive		
Carfentanil	male, 45 years old	Whole blood	90 pg/mL	Morphine (free): 124 ng/mL Morphine (total): 161 ng/mL Noscapine metabolites and papaverine metabolites: positive Diazepam: 75 ng/mL Nordiazepam: 75 ng/mL Temazepam: 9 ng/mL Oxazepam: 9 ng/mL Codeine: 194 ng/mL Zopiclone: 11.3 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	6835 pg/mL	Carfentanil metabolites: positive 6-monoacetylmorphine: positive		
Carfentanil	female, 21 years old	Whole blood	581 pg/mL	6-monoacetylmorphine: positive Morphine: <LoD Cocaine: 5 ng/mL Benzoylecgonine: 31 ng/mL Buprenorphine: 1.0 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Carfentanil	male, 53 years old	Whole blood	790 pg/mL	Ethanol: 2.03 g/L Morphine (free): 21 ng/mL Morphine (total): 21 ng/mL Noscapine metabolites and papaverine metabolites: positive Codeine: 8 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	490 pg/mL	Ethanol: 2.11 g/L 6-monoacetylmorphine: positive 4F-butyrfentanyl: positive		
Carfentanil	male, 40 years old	Whole blood	4004 pg/mL	Ethanol: 0.07 g/L Morphine (free): 71 ng/mL Morphine (total): 94 ng/mL 6-monoacetylmorphine: positive Noscapine metabolites and papaverine metabolites: positive Paracetamol: 10.7 mg/L Pregabalin: 10.6 mg/L THC-COOH: 7.1 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	2742 pg/mL	Ethanol: 0.13 g/L		
Carfentanil	male, 51 years old	Whole blood	182 pg/mL	Butyrfentanyl: positive (see Table 2) 4F-butyrfentanyl: positive Morphine (free): 25 ng/mL Morphine (total): 27 ng/mL Noscapine metabolites: positive Diazepam: 32 ng/mL Nordiazepam: 32 ng/mL Methadone: 29 ng/mL EDDP: 33 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	male, 47 years old	Whole blood	234 pg/mL	Ethanol: 0.15 g/L Morphine (free): 88 ng/mL Morphine (total): 106 ng/mL 6-monoacetylmorphine: positive Noscapine metabolites and papaverine metabolites: positive Codeine: 11 ng/mL Dihydrocodeine: 7 ng/mL Diazepam: 36 ng/mL Nordiazepam: 96 ng/mL Temazepam: <5 ng/mL Oxazepam: 11 ng/mL Paracetamol: 10.8 mg/L Pregabalin: 1.9 mg/L	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	male, 54 years old	Whole blood	691 pg/mL	Citalopram: 67 ng/mL Norcitalopram: 15 ng/mL Diazepam: <5 ng/mL Nordiazepam: 9 ng/mL Propranolol: 41 ng/mL Amitriptyline: 20 ng/mL Nortriptyline: 9 ng/mL THC: 9.5 ng/mL THC-COOH: 26.0 ng/mL Sertraline: 453 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	5368 pg/mL	Carfentanil metabolites: positive		
Carfentanil	male, 44 years old	Whole blood	96 pg/mL	Duloxetine: 92 mg/L Paracetamol: 15.5 mg/L	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
		Urine	839 pg/mL			

Carfentanil	male, 25 years old	Antemortem EDTA sample	21 pg/mL	Alfentanil: positive	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	male, 34 years old	Whole blood	1118 pg/mL	Ethanol: 0.30 g/L Morphine (free): 185 ng/mL Morphine (total): 196 ng/mL 6-monoacetylmorphine: positive Noscapine metabolites and papaverine metabolites: positive Codeine: 10 ng/mL Diazepam: 28 ng/mL Nordiazepam: 49 ng/mL Mirtazapine: 40 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	female, 37 years old	Antemortem serum	98 pg/mL	Morphine: <LoD Gabapentin: 6.8 mg/L Cocaine: <5 ng/mL Benzoylecgonine: 442 ng/mL Sertraline: 18 ng/mL Zopiclone: 17 ng/mL Risperidone: 42.1 ng/mL Amitriptyline: <5 ng/mL Nortriptyline: 5 ng/mL	Carfentanil toxicity (for some cases in combination with other synthetic fentanyls and other toxicology findings) likely the cause of death	[87]
Carfentanil	N=355	Blood	<0.10-14 ng/mL (not exclusively death cases)			[88]
Carfentanil	female, 26 years old	Iliac blood	234 ng/L	Iliac blood: THC-COOH: 10.1 ng/mL Topiramate: 7.5 mg/L Urine: Buprenorphine: positive Norbuprenorphine: positive THC-COOH: positive Norfentanyl: positive Morphine: positive	Carfentanil intoxication, accident	[89]
Carfentanil	male, 38 years old	Femoral blood	221 ng/L	Urine: Morphine: positive Codeine: positive Hydromorphone: positive Norfentanyl: positive	Carfentanil drug toxicity, accident	[89]
Carfentanil	female, 36 years old	Femoral blood	107 ng/L	Femoral blood: THC: 4.9 ng/mL THC-COOH: 67.5 ng/mL Urine: Temazepam: positive Nordiazepam: positive Oxazepam: positive Buprenorphine: positive Norbuprenorphine: positive THC-COOH: positive Norfentanyl: positive Morphine: positive Hydromorphone: positive	Carfentanil drug toxicity, accident	[89]
Carfentanil	female, 33 years old	Iliac blood	145 ng/L	Iliac blood: Morphine: 10.9 ng/mL THC: 2.7 ng/mL THC-COOH: 29.0 ng/mL Urine: THC-COOH: positive Morphine: positive Codeine: positive	Mixed drug intoxication, accident	[89]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Carfentanil	male, 25 years old	Heart blood	241 ng/L	Heart blood: Benzoylecgonine: 54.3 ng/mL Naloxone: positive Caffeine: positive Urine: Benzoylecgonine: positive Norfentanyl: positive	Cocaine and carfentanil intoxication, accident	[89]
Carfentanil	female, 44 years old	Femoral blood	105 ng/L	Cotinine: positive	Carfentanil intoxication, accident	[89]
Carfentanil	male, 28 years old	Iliac blood	23.3 ng/L	THC-COOH: 9.6 ng/mL	Acute carfentanil intoxication, accident	[89]
Carfentanil	male, 38 years old	Subclavian blood	30.1 ng/L	Urine: Morphine: positive Hydromorphone: positive Fentanyl: positive Norfentanyl: positive	Acute carfentanil toxicity, accident	[89]
Carfentanil	male, 44 years old	Femoral blood	114 ng/L	Furanylfentanyl: 0.61 ng/mL (see Table 2) Alprazolam: 3.4 ng/mL THC: 2.6 ng/mL THC-COOH: 3.4 ng/mL Codeine: 40.0 ng/mL Buprenorphine: 0.6 ng/mL Phenytoin: 4.0 mg/L Quetiapine: 370 ng/mL Naloxone: positive Nicotine: positive Cotinine: positive	Multiple drug (carfentanil, furanylfentanyl, codeine, buprenorphine and alprazolam) intoxication, accident	[89]
Carfentanil	male, 50 years old	Subclavian blood	617 ng/L	Subclavian blood: Fentanyl: 2.9 ng/mL Urine: Ethanol: 0.2 g/L Fentanyl: positive Norfentanyl: positive	Fentanyl and carfentanil toxicity, accident	[89]
Carfentanil	male, 27 years old	Femoral blood	529 ng/L	Femoral blood: THC-COOH: 10.1 ng/mL Urine: THC-COOH: positive Fentanyl: positive Norfentanyl: positive Morphine: positive	Carfentanil toxicity, accident	[89]
Carfentanil	female, 62 years old	Femoral blood	45.7 ng/L	Fentanyl: 1.1 ng/mL	Carfentanil and fentanyl toxicity, accident	[89]
Carfentanil	male, 39 years old	Femoral blood	10.4 ng/L	Ethanol: 1.54 g/L Amitriptyline: 29.9 ng/mL Nicotine: positive Cotinine: positive Urine: Ethanol: 2.91 g/L	Mixed drug (carfentanil and ethanol) intoxication, accident	[89]
Carfentanil	N=31	Whole blood	mean 0.34 ng/mL			[61]

Carfentanil	female, 31 years old	Heart blood	1.9 ng/mL	Fentanyl: <1.0 ng/mL	Acute intoxication by the combined effects of carfentanil, heroin, benzodiazepines and cyclobenzaprine	[61]
		Femoral blood	0.36 ng/mL	Fentanyl: <1 ng/mL Morphine: 88 ng/mL Codeine: <10 ng/mL 6-acetylmorphine: <4 ng/mL Clonazepam: 19 ng/mL Oxazepam: 22 ng/mL Temazepam: 110 ng/mL Cyclobenzaprine: 100 ng/mL		
Carfentanil	male, 21 years old	Blood	92 ng/mL	Norcarfentanil: 0.532 ng/mL	Suicide	[90]
		Urine	2.8 ng/mL	Norcarfentanil: not detected Blood or urine: Caffeine: positive Theobromine: positive Propranolol: positive Sertraline: positive Cannabinoids: positive		
		Vitreous humor	23 ng/mL	Norcarfentanil: 0.300 ng/mL		
Carfentanil	male, 40 years old	Femoral blood	3.3 ng/mL	Morphine: 171 ng/mL Morphine-3-Glucuronide: 231 ng/mL Morphine-6-Glucuronide: <30 ng/mL 6-monoacetylmorphine: positive Noscapine: positive Papaverine: positive Codeine: positive Methadone: 0.07 mg/L Cannabinoids: positive Cocaine: positive Benzoylecgonine: positive Olanzapine: positive Tramadol: positive Mirtazapine: positive Diazepam: positive Paracetamol: positive		[91]
Carfentanil	male, 36 years old	Femoral blood	0.80 ng/mL	Blood: Morphine: 112 ng/mL Morphine-3-Glucuronide: 187 ng/mL Morphine-6-Glucuronide: 24 ng/mL Noscapine: positive Papaverine: positive Codeine-Glucuronide: positive Methadone: 0.50 mg/L Cocaine: positive Benzoylecgonine: positive Levamisole: positive 7-Aminonitrazepam: positive 7-Aminoclonazepam: positive Trazodone: positive Nortriptyline: positive Diazepam: positive Ibuprofen: positive Urine: 6-monoacetylmorphine: positive		[91]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Carfentanil	male, 36 years old	Femoral blood	0.22 ng/mL	Blood: Morphine: 15 ng/mL Morphine-3-Glucuronide: 52 ng/mL Morphine-6-Glucuronide: <10 ng/mL Cannabinoids: positive Clozapine: positive Urine: 6-monoacetylmorphine: positive		[91]
Carfentanil	female, 44 years old	Femoral blood	0.82 ng/mL	Morphine: 52 ng/mL Morphine-3-Glucuronide: 107 ng/mL Morphine-6-Glucuronide : 37 ng/mL Noscapine: positive Papaverine: positive Dihydrocodeine: 1.47 mg/L Cocaine: positive Benzoylecgonine: positive Mebeverine: positive Diazepam: positive		[91]
Carfentanil	male, 29 years old	Femoral blood	0.24 ng/mL	Morphine: 170 ng/mL Morphine-3-Glucuronide : 1125 ng/mL Morphine-6-Glucuronide : 251 ng/mL Noscapine: positive Papaverine: positive Codeine: positive Ketamine: 7.94 mg/L Norketamine: 5.49 mg/L Amphetamine: positive Alprazolam: positive		[91]
Carfentanil	male, 37 years old	Femoral blood	0.50 ng/mL	Noscapine: positive Cannabinoids: positive Sertraline: positive Paracetamol: positive		[91]
		Aorta blood	1.05 ng/mL			
		Right ventricle blood	0.57 ng/mL			
Carfentanil	female, 31 years old	Femoral blood	0.66 ng/mL	Morphine: 44 ng/mL Morphine-3-Glucuronide : 14 ng/mL Morphine-6-Glucuronide : <10 ng/mL Methadone: 0.25 mg/L Cocaine: positive Benzoylecgonine: positive Amitriptyline: positive		[91]
Cyclopropylfentanyl	male, 46 years old	Iliac blood	6.8 ng/mL	Blood: Ethanol: 1.32 g/L Mitragynine: 890 ng/mL		[76]
Cyclopropylfentanyl	female, 44 years old	Iliac blood	13.6 ng/mL	Blood: Cocaine: 730 ng/mL Benzoylecgonine: 1700 ng/mL Fentanyl: 3.0 ng/mL Norfentanyl: 1.3 ng/mL		[76]
Cyclopropylfentanyl	male, 43 years old	Iliac blood	24.7 ng/mL	Blood: Methoxyacetylfentanyl: positive (see Table 2) Ethanol: 0.11 g/L 7-aminoclonazepam: 13 ng/mL Cocaine: 70 ng/mL Benzoylecgonine: 1200 ng/mL Hydroxyzine: 320 ng/mL Cyclobenzaprine: 23 ng/mL		[76]

Cyclopropylfentanyl	male, 22 years old	Cardiac blood	11.6 ng/mL	Blood: Delorazepam: 150 ng/mL Lorazepam: 89 ng/mL Morphine: 24 ng/mL THC: 1.7 ng/mL THC-COOH: 26 ng/mL Hydroxy-THC: 1.2 ng/mL Methamphetamine: 75 ng/mL Amphetamine: 66 ng/mL		[76]
Cyclopropylfentanyl	male, 52 years old	Femoral blood	5.4 ng/mL	Blood: Cocaine: 190 ng/mL Cocaethylene: 32 ng/mL Benzoylecgonine: 3100 ng/mL		[76]
Cyclopropylfentanyl	female, 31 years old	Iliac blood	10.7 ng/mL	Blood: Cocaine: 310 ng/mL Benzoylecgoninge: 3200 ng/mL Fentanyl: 1.9 ng/mL Norfentanyl: 1.0 ng/mL		[76]
Cyclopropylfentanyl	female	Femoral blood	23.2 ng/mL	Blood: Cocaine: 38 ng/mL Benzoylecgonine: 400 ng/mL Hydroxyzine: 130 ng/mL		[76]
Cyclopropylfentanyl	male, 36 years old	Iliac blood	20.2 ng/mL	Blood: Methoxyacetylfentanyl: positive (see Table 2) Ethanol: 2.90 g/L Cocaethylene: 31 ng/mL Benzoylecgonine: 99 ng/mL		[76]
Cyclopropylfentanyl	male, 61 years old	Iliac blood	42.8 ng/mL	Blood: Methoxyacetylfentanyl: positive (see Table 2) Alprazolam: 13 ng/mL Cocaine: 160 ng/mL Benzoylecgonine: 1500 ng/mL Hydromorphone: 15 ng/mL Oxycodone: 220 ng/mL		[76]
Cyclopropylfentanyl	male, 32 years old	Iliac blood	22.7 ng/mL	Blood: Oxycodone: 16 ng/mL		[76]
Cyclopropylfentanyl	male, 52 years old	Peripheral blood	9.9 ng/mL	Blood: para-Fluoroisobutyrylfentanyl (FIBF): 18 ng/mL (see Table 2) Morphine: 73 ng/mL Fluoxetine: 63 ng/mL Norfluoxetine: 120 ng/mL Diphenhydramine: 670 ng/mL Fentanyl: 10 ng/mL Norfentanyl: 3.0 ng/mL	Accidental polydrug intoxication	[76]
Cyclopropylfentanyl	male, 32 years old	Peripheral blood	37.2 ng/mL	Blood Ethanol: 0.37 g/L Flubromazolam: 3.5 ng/mL (see Table 3) Codeine: 11 ng/mL Morphine: 310 ng/mL 6-monoacetylmorphine: 3.9 ng/mL Diphenhydramine: 350 ng/mL	Combined drug toxicity; accident	[76]
Cyclopropylfentanyl	male, 49 years old	Peripheral blood	23.0 ng/mL	Blood: Alprazolam: 8.2 ng/mL Morphine: 21 ng/mL Diphenhydramine: 210 ng/mL	Combined drug toxicity; accident	[76]
Cyclopropylfentanyl	male, 43 years old	Peripheral blood	4.0 ng/mL	Blood: Flubromazolam: 4.9 ng/mL (see Table 3) Codeine: 14 ng/mL Morphine: 230 ng/mL 6-monoacetylmorphine: 8.1 ng/mL 10-Hydroxycarbazepine: 15 ng/mL Quetiapine: 610 ng/mL Diphenhydramine: 97 ng/mL	Combined drug toxicity; accident	[76]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Cyclopropylfentanyl	male, 28 years old	Peripheral blood	13.1 ng/mL	Blood: 7-aminoclonazepam: 31 ng/mL Cocaine: 51 ng/mL Benzoylecgonine: 1500ng/mL Morphine: 16 ng/mL Diphenhydramine: 16 ng/mL Urine: 6-monoacetylmorphine: 120 ng/mL	Combined drug toxicity; accident	[76]
Cyclopropylfentanyl	female, 50 years old	Peripheral blood	14.7 ng/mL	Blood: Clonazepam 2.8 ng/mL 7- aminoclonazepam: 91 ng/mL Benzoylecgonine: 500 ng/mL Morphine: 60 ng/mL 6-monoacetylmorphine: 7.9 ng/mL Olanzapine: 8.6 ng/mL Desmethylsertraline: 110 ng/mL Diphenhydramine: 120 ng/mL		[76]
Cyclopropylfentanyl	male, 32 years old	Peripheral blood	43.3 ng/mL	Blood: Alprazolam: 47 ng/mL Morphine: 55 ng/mL 6-monoacetylmorphine: 1.5 ng/mL Diphenhydramine: 210 ng/mL	Combined drug toxicity; accident	[76]
Cyclopropylfentanyl	male	Peripheral blood	6.9 ng/mL	Blood: Morphine: 9.8 ng/mL Urine: 6-monoacetylmorphine: 41 ng/mL		[76]
Cyclopropylfentanyl	male, 36 years old	Peripheral blood	6.1 ng/mL	Blood: para-Fluoroisobutyrylfentanyl (FIBF): 7.5 ng/mL (see Table 2) Cocaine: 170 ng/mL Benzoylecgonine: 240 ng/mL Morphine: 12 ng/mL Diphenhydramine: 120 ng/mL Fentanyl: 3.6 ng/mL Acetylfentanyl: 0.31 ng/mL (see Table 2) Urine: 6-monoacetylmorphine: 15 ng/mL	Accidental drug overdose	[76]
Cyclopropylfentanyl	male, 19 years old	Peripheral blood	13.5 ng/mL	Blood: Diazepam: 65 ng/mL Nordiazepam: 89 ng/mL THC: 9.7 ng/mL THC-COOH: 61 ng/mL Hydroxy-THC: 4.8 ng/mL Diphenhydramine: 57 ng/mL		[76]
Cyclopropylfentanyl	male, 46 years old	Peripheral blood	1.4 ng/mL	Blood: Cocaine: 130 ng/mL Benzoylecgonine: 690 ng/mL Diphenhydramine: 78 ng/mL Fentanyl: 22 ng/mL		[76]
Cyclopropylfentanyl	male, 25 years old	Peripheral blood	5.4 ng/mL	Blood: THC: 4.2 ng/mL THC-COOH: 10 ng/mL Hydroxy-THC: 1.3 ng/mL		[76]

Cyclopropylfentanyl	male, 45 years old	Femoral blood	5.6 ng/mL	Blood: Ethanol: 0.52 g/L Cocaine: 440 ng/mL Cocaethylene: 160 ng/mL Benzoylecgonine: 1500 ng/mL THC: 2.8 ng/mL THC-COOH: 5.3 ng/mL Hydroxy-THC: 1.3 ng/mL Diphenhydramine: 71 ng/mL	[76]
Cyclopropylfentanyl	female, 32 years old	Femoral blood	3.3 ng/mL	Blood: Alprazolam: 46 ng/mL Morphine: 11 ng/mL Fentanyl: 10 ng/mL Norfentanyl: 0.37 ng/mL	[76]
Cyclopropylfentanyl	female, 53 years old	Peripheral blood	33.6 g/mL	Blood: Ethanol: 0.56 g/L Cocaine: 74 ng/mL Benzoylecgonine: 200 ng/mL Mirtazapine: 91 ng/mL Chlorpheniramine: 18 ng/mL Hydroxyzine: 71 ng/mL Fentanyl: 4.1 ng/mL Morphine: 6.3 ng/mL	[76]
Cyclopropylfentanyl	female	Peripheral blood	1.9 ng/mL	Blood: Trazodone: 0.24 μg/mL Buprenorphine: 0.85 ng/mL Norbuprenorphine: 1.1 ng/mL Fentanyl: 0.93 ng/mL Morphine: 15 ng/mL Vitreous humor: Morphine: 11 ng/mL 6-monoacetylmorphine: 1.1 ng/mL	[76]
Cyclopropylfentanyl	male, 54 years old	Peripheral blood	15.7 ng/mL	Blood: Cocaine: 60 ng/mL Benzoylecgonine: 2400 ng/mL Lamotrigine: 1.4 ng/mL Fluoxetine: 41 ng/mL Norfluoxetine: 38 ng/mL Aripiprazole: 120 ng/mL Diphenhydramine: 360 ng/mL Hydrocodone: 5.7 ng/mL	[76]
Cyclopropylfentanyl	male, 63 years old	Peripheral blood	31.5 ng/mL	Blood: Ethanol: 0.25 g/L U-47700: 24 ng/mL (see Table 2) Cocaine: 25 ng/mL Benzoylecgonine: 58 ng/mL	[76]
Cyclopropylfentanyl	male, 57 years old	Peripheral blood	18.5 ng/mL	Blood: U-47700: 7.8 ng/mL (see Table 2) Cocaine: 130 ng/mL Benzoylecgonine: 910 ng/mL Fentanyl: 6.2 ng/mL Norfentanyl: 5.5 ng/mL	[76]
Cyclopropylfentanyl	female, 29 years old	Femoral blood	5.3 ng/mL	Blood: Methoxyacetylfentanyl: 0.21 ng/mL (see Table 2) Codeine: 20 ng/mL Morphine: 470 ng/mL 6-monoacetylmorphine: 8.4 ng/mL Hydromorphone: 2.1 ng/mL	[76]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Cyclopropylfentanyl	male, 38 years old	Femoral blood	5.0 ng/mL	Blood: Gabapentin: 7.2 μg/mL 7-aminoclonazepam: 8.5 ng/mL Sertraline: 290 ng/mL Desmethylsertraline: 520 ng/mL THC: 2.6 ng/mL		[76]
Cyclopropylfentanyl	male, 26 years old	Abdominal aorta blood	8.5 ng/mL	Blood: Furanylfentanyl: 0.52 ng/mL (see Table 2) Cocaine: 85 ng/mL Benzoylecgonine: 530 ng/mL Methadone: 65 ng/mL EDDP: <20 ng/mL THC: 1.4 ng/mL THC-COOH: 20 ng/mL Fentanyl: 4.4 ng/mL Norfentanyl: 0.75 ng/mL		[76]
Cyclopropylfentanyl	male, 29 years old	Femoral blood	0.10 ng/mL	Alprazolam Quetiapine Gabapentin Duloxetine Methoxyacetylfentanyl: 14 ng/mL (see Table 2) para-Fluoroisobutyrylfentanyl (FIBF): 27 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 9.7 ng/mL		[94]
		Cardiac blood	0.15 ng/mL	Methoxyacetylfentanyl: 70 ng/mL (see Table 2) para-Fluoroisobutyrylfentanyl (FIBF): 31 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 5.1 ng/mL		
		Urine	positive	Methoxyacetylfentanyl: positive (see Table 2) para-Fluoroisobutyrylfentanyl (FIBF): positive (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive p-Fluorofentanyl: positive Isobutyrylfentanyl: positive Butyrfentanyl: positve (see Table 2) Valerylfentanyl: positive		
ortho-Fluorofentanyl	male	Blood	2.4 ng/mL	Alprazolam: 16 ng/mL Desmethyldiazepam: 3.8 ng/mL 7-Aminoclonazepam: 34 ng/mL THC: 21 ng/mL GHB: 22 μg/mL	Caused by ortho-fluorofentanyl	[92]
		Urine	3.9 ng/mL	Ethanol: positive THC-COOH: positive GHB: positive		
Fluorofentanyl	male, 34 years old	Femoral blood	approx. 30 ng/mL	Nicotine: positive Caffeine: positive Amitriptyline: positive Opipramol: positive Nordiazepam: positive Amphetamine: positive THC-COOH: positive	Acute poisoning by fluorofentanyl; suicide	[93]
		Urine	approx. 40 ng/mL			
		Gastric contents	approx. 5700 ng/mL			
		Bile fluid	approx. 300 ng/mL			
		Heart blood	approx. 30 ng/mL			
		Liver	approx. 80 ng/mg			
		Liquor	approx. 5 ng/mL			

Fluorofentanyl	female, 33 years old	Femoral blood	approx. 30 ng/mL	Nicotine: positive Caffeine: positive Amitriptyline: positive Opipramol: positive	Acute poisoning by fluorofentanyl; suicide	[93]
		Urine	approx. 30 ng/mL			
		Gastric contents	approx. 1300 ng/mL			
		Bile fluid	approx. 180 ng/mL			
		Heart blood	approx. 40 ng/mL			
		Liver	approx. 20 ng/mg			
		Liquor	approx. 10 ng/mL			
para-Fluoroisobutyrylfentanyl (FIBF)	male, 52 years old	Peripheral blood	18 ng/mL	Blood: Cyclopropylfentanyl: 9.9 ng/mL (see Table 2) Morphine: 73 ng/mL Fluoxetine: 63 ng/mL Norfluoxetine: 120 ng/mL Diphenhydramine: 670 ng/mL Fentanyl: 10 ng/mL Norfentanyl: 3.0 ng/mL	Accidental polydrug intoxication	[76]
para-Fluoroisobutyrylfentanyl (FIBF)	male, 36 years old	Peripheral blood	7.5 ng/mL	Blood: Cyclopropylfentanyl: 6.1 ng/mL (see Table 2) Cocaine: 170 ng/mL Benzoylecgonine: 240 ng/mL Morphine: 12 ng/mL Diphenhydramine: 120 ng/mL Fentanyl: 3.6 ng/mL Acetylfentanyl: 0.31 ng/mL (see Table 2) Urine: 6-monoacetylmorphine: 15 ng/mL	Accidental drug overdose	[76]
para-Fluoroisobutyrylfentanyl (FIBF)	male, 31 years old	Femoral blood	26 ng/g	Blood: Acrylfentanyl: 0.19 ng/g (seeTable 2) Alimemazine: 0.3 μg/g Desmethylalimemazine: 0.1 μg/g Oxycodone: 0.017 μg/g Gabapentin: 0.79 μg/g Duloxetine: 0.22 μg/g Ethanol: 1.91 ‰ Urine: Ethanol: 2.47 ‰	Intoxication with alcohol and several drugs: benzodiazepine, acrylfentanyl	[77]
para-Fluoroisobutyrylfentanyl (FIBF)	male, 29 years old	Femoral blood	27 ng/mL	Alprazolam: positive Quetiapine: positive Gabapentin: positive Duloxetine: positive Methoxyacetylfentanyl: 14 ng/mL (see Table 2) Cyclopropylfentanyl: 0.10 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 9.7 ng/mL	Pneumonia, secondary to drug intoxication	[94]
		Cardiac blood	31 ng/mL	Methoxyacetylfentanyl: 70 ng/mL (see Table 2) Cyclopropylfentanyl: 0.15 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 5.1 ng/mL		
		Urine	positive	Methoxyacetylfentanyl: positive (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Cyclopropylfentanyl: positive (see Table 2) p-Fluorofentanyl: positive Isobutyrylfentanyl: positive Butyrfentanyl: positve (see Table 2) Valerylfentanyl: positive		

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Furanylfentanyl	male, 34 years old	Heart blood	0.34 ng/mL	Heart blood: Carfentanil: 1.3 ng/mL (see Table 2) Fentanyl: 6 ng/mL Morphine (total): <20 ng/mL Hydromorphone (total): <20 ng/mL Vitreous humor: 6-monoacetylmorphine, hydrocodone and hydromorphone: positive Urine: Morphine (total), hydromorphone (total), 6-monoacetylmorphine, hydrocodone and hydromorphone: positive Peripheral blood: Fentanyl, morphine (total), hydromorphone (total), 6-monoacetylmorphine, hydrocodone and hydromorphone: not detected	Intoxication by the combined effects of heroin, fentanyl, carfentanil and furanylfentanyl; accident	[86]
Furanylfentanyl	male, 36 years old	Aorta blood	26 ng/mL	U-47700: 135 ng/mL (see Table 2) Ethanol: positive Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive		[66]
Furanylfentanyl	male, 33 years old	Aorta blood	56 ng/mL	U-47700: 167 ng/mL (see Table 2) Morphine: 48 ng/mL Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive 6-monoacetylmorphine: positive Quinine: positive		[66]
Furanylfentanyl	male, 29 years old	Aorta blood	76 ng/mL	U-47700: 490 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive		[66]
Furanylfentanyl	male, 40 years old	Aorta blood	2.5 ng/mL	U-47700: 105 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive		[66]
Furanylfentanyl	male, 30 years old	Peripheral blood	6.1 ng/mL	THC: 1 ng/mL Tramadol: 75 ng/mL O-Desmethyltramadol: 40 ng/mL Butyrfentanyl: 0.33 ng/mL (see Table 2)		[66]
Furanylfentanyl	male, 32 years old	Femoral blood	12.9 ng/mL	THC: 9.6 ng/mL THC-COOH: 13 ng/mL Diphenhydramine: 140 ng/mL Acetyl fentanyl: 0.65 ng/mL (see Table 2) Naloxone: positive	Acute intoxication of combined effects of acetyl fentanyl and diphenhydramine	[66]
Furanylfentanyl	male, 26 years old	Peripheral blood	6.2 ng/mL	Blood: Alprazolam: 25 ng/mL Hydrocodone: 120 ng/mL Hydromorphone: 1.8 ng/mL Dihydrocodeine: 21 ng/mL Venlafaxine: 83 ng/mL O-Desmethylvenlafaxine: 400 ng/mL THC-COOH: 7.2 ng/mL Diphenhydramine: 90 ng/mL Caffeine: positive Nicotine: positive Urine: Presumptively positive for opiates, benzodiazepines, cannabinoids, fentanyl/metabolites		[66]

Furanylfentanyl	male, 26 years old	Blood	1.00 ng/g	Blood. THC: 0.0006 μg/g Mirtazapine: 0.07 μg/g Desmethylmirtazapine: 0.03 μg/g Pregabalin: 5.7 μg/g Buprenorphine: 0.0019 μg/g Norbuprenorphine: 0.0027 μg/g Clonazepam: 0.02 μg/g 7-Aminoclonazepam: 0.59 μg/g Urine: Buprenorphine: 0.03 μg/mL Norbuprenorphine: 0.18 μg/mL	Intoxication with furanylfentanyl, possibly in combination with the other drugs	[95]
Furanylfentanyl	male, 36 years old	Blood	2.74 ng/g	Pregabalin: 14 μg/g	Furanylfentanyl intoxication	[95]
Furanylfentanyl	male, 37 years old	Blood	0.90 ng/g	Pregabalin: 32 μg/g Amphetamine: 0.11 μg/g Carbamazepine: 9 μg/g Venlafaxine: 1.0 μg/g Alimemazine: 0.3 μg/g Promethazine: 0.06 μg/g Desmethylpromethazine: 0.1 μg/g Methylphenidate: 0.027 μg/g Ritalinic acid: 0.72 μg/g 7-aminoclonazepam: 0.09 μg/g Paracetamol: 8 μg/g	Fatal intoxication of furanylfentanyl and pregabalin, along with a possible interaction with some of the other drugs	[95]
Furanylfentanyl	male, 26 years old	Blood	0.41 ng/g	Ethanol: 0.27‰	Furanylfentanyl intoxication	[95]
Furanylfentanyl	male, 26 years old	Blood	0.74 ng/g	Blood: Fentanyl: 0.38 ng/g Norbuprenorphine: 1.3 ng/g Pregabalin: 27 μg/g Carbamazepine: 14 μg/g Gabapentin: 90 μg/g Alimemazine: 0.2 μg/g Desmethylalimemazine: 0.2 μg/g Alprazolam: 0.04 μg/g Diazepam: 0.03 μg/g Methylphenidate: 0.004 μg/g Ritalinic acid: 0.22 μg/g Urine: Buprenorphine: 0.006 μg/mL Norbuprenorphine: 0.03 μg/mL Hair: 7-aminoclonazepam: positive Alprazolam: positive Zopiclone: positive Fentanyl: positive	Fatal intoxication of fentanyl/ furanylfentanyl in combination with carbamazepine and pregabalin	[95]
Furanylfentanyl	male, 27 years old	Blood	1.1 ng/g	–	Fatal intoxication of furanylfentanyl; possibility of suicide	[95]
Furanylfentanyl	male, 24 years old	Blood	0.38 ng/g	Blood: Fentanyl: 1.2 ng/g Urine: Ethanol: 0.15‰ Hair: Fentanyl: positive Amphetamine: positive	Fentanyl and furanylfentanyl intoxication with subsequent inhalation of gastric contents into the airways	[95]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Furanylfentanyl	male, 26 years old	Peripheral blood	0.95 ng/mL	Peripheral blood: Acrylfentanyl (see Table 2): 0.32 ng/mL Naloxone: positive Nicotine: positive Cotinine: positive Urine: Morphine: positive Hydromorphone: positive	Acrylfentanyl and furanylfentanyl toxicity; accident	[78]
Furanylfentanyl	male, 23 years old	Peripheral blood	1.9 ng/mL	Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 4.3 ng/mL Codeine: <50 ng/mL Amphetamine: <20 ng/mL Methamphetamine: <50 ng/mL THC: 4 ng/mL THC-COOH: 17 ng/mL Nicotine: positive Cotinine: positive Caffeine: positive	Acute furanylfentanyl toxicity	[96]
		Cardiac blood	2.8 ng/mL	Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 5.8 ng/mL		
		Gastric contents	Approx. 55000 ng			
		Urine	positive	Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Methamphetamine: positive Nicotine: positive Cotinine: positive Caffeine: positive		
		Vitreous humor	<0.20 ng/mL	Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): <0.20 ng/mL		
		Liver	negative	Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): >40 ng/g		
Furanylfentanyl	N=9	Whole blood	2.0-42.9 ng/mL		Drug intoxication, accident	[97] (abstract only)
Furanylfentanyl	N=12	Whole blood	mean 0.20 ng/mL			[61]
Furanylfentanyl	female, 53 years old	Heart blood	8.7 ng/mL	Fentanyl: <1.0 ng/mL Norfentanyl: 0.55 ng/mL	Acute intoxication due to the combined effects of heroin, fentanyl, diphenhydramine and furanylfentanyl, accident	[61]
		Femoral blood	5.5 ng/mL	Fentanyl: 1.3 ng/mL Norfentanyl: 0.34 ng/mL Morphine: <10 ng/mL Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Nicotine: positive Cotinine: positive Diphenhydramine: <50 ng/mL		
		Vitreous humor	approx. 30 ng/mL	Fentanyl: 1.4 ng/mL Norfentanyl: 0.91 ng/mL Morphine: 16 ng/mL 6-acetylmorphine: <10 ng/mL		

Furanylfentanyl	male, 26 years old	Abdominal aorta blood	0.52 ng/mL	Blood: Cyclopropylfentanyl: 8.5 ng/mL (see Table 2) Cocaine: 85 ng/mL Benzoylecgonine: 530 ng/mL Methadone: 65 ng/mL EDDP: <20 ng/mL THC: 1.4 ng/mL THC-COOH: 20 ng/mL Fentanyl: 4.4 ng/mL Norfentanyl: 0.75 ng/mL		[76]
Furanylfentanyl	male, 44 years old	Femoral blood	0.61 ng/L	Carfentanil: 114 ng/mL (see Table 2) Alprazolam: 3.4 ng/mL THC: 2.6 ng/mL THC-COOH: 3.4 ng/mL Codeine: 40.0 ng/mL Buprenorphine: 0.6 ng/mL Phenytoin: 4.0 mg/L Quetiapine: 370 ng/mL Naloxone: positive Nicotine: positive Cotinine: positive	Multiple drug (carfentanil, furanylfentanyl, codeine, buprenorphine and alprazolam) intoxication, accident	[89]
Methoxyacetylfentanyl	male	Femoral blood	0.022 mg/kg	Chlordiazepoxide: 0.036 mg/kg Demoxepam: 0.11 mg/kg 7-aminoclonazepam: 0.045 mg/kg Nordazepam: 0.019 mg/kg Benzoylecgonine: 0.041 mg/kg THC: 0.0062 mg/kg Promethazine: 0.021 mg/kg Ethanol: 0.87 mg/kg	Methoxyacetylfentanyl overdose supposed as contributing to the cause of death	[98]
		Brain tissue	0.074 mg/kg			
Methoxyacetylfentanyl	male	Femoral blood	0.023 mg/kg	7-aminoclonazepam: 0.11 mg/kg Amphetamine: 0.0045 mg/kg Benzoylecgonine: 0.14 mg/kg Cocaine: 0.0035 mg/kg Diazepam: 0.058 mg/kg MDMA: 0.017 mg/kg MDA: 0.0055 mg/kg Nordazepam: 0.12 mg/kg Sildenafil: 0.054 mg/kg	Serious or lethal intoxication with methoxyacetylfentanyl	[98]
		Urine	0.12 mg/kg			
Methoxyacetylfentanyl	male	Femoral blood	0.056 mg/kg	Peripheral blood: 7-aminoclonazepam: 0.052 mg/kg Alprazolam: 0.0041 mg/kg Amphetamine: 0.31 mg/kg Benzoylecgonine: 0.0038 mg/kg Diazepam: 0.018 mg/kg Dimethylaminodiphenylbutene (A29): 0.067 mg/kg Fentanyl: 0.0016 mg/kg Furosemide: 1.3 mg/kg Lidocaine: 0.033 mg/kg Nordazepam: 0.015 mg/kg Quetiapine: 0.037 mg/kg Salicylic acid: 3.9 mg/kg	Intoxication with a combination of methoxyacetylfentanyl, fentanyl, amphetamine, and benzodiazepines	[98]
Methoxyacetylfentanyl	female, 29 years old	Femoral blood	0.21 ng/mL	Blood: Cyclopropylfentanyl: 5.3 ng/mL (see Table 2) Codeine: 20 ng/mL Morphine: 470 ng/mL 6-monoacetylmorphine: 8.4 ng/mL Hydromorphone: 2.1 ng/mL		[76]
Methoxyacetylfentanyl	male, 38 years old	Femoral blood	12 ng/mL	–	Methoxyacetylfentanyl overdose	[76]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Methoxyacetylfentanyl	male, 30 years old	Femoral blood	39.9 ng/mL	Blood: Ethanol: 0.31 g/L Oxycodone: 35 ng/mL	Methoxyacetylfentanyl intoxication	[76]
Methoxyacetylfentanyl	male, 38 years old	Femoral blood	11.9 ng/mL	Blood: Ethanol: 1.35 g/L Benzoylecgonine: 170 ng/mL Morphine: 15 ng/mL	Lethal combination of alcohol, cocaine, morphine and methoxyacetylfentanyl	[76]
Methoxyacetylfentanyl	male, 53 years old	Femoral blood	11.5 ng/mL	Blood: Acrylfentanyl: 0.64 ng/mL (see Table 2) Morphine: 13 ng/mL Fentanyl: 2.0 ng/mL Norfentanyl: 0.31 ng/mL Methamphetamine: 23 ng/mL	Acrylfentanyl, methoxyacetylfentanyl, heroin, fentanyl and methamphetamine toxicity	[76]
Methoxyacetylfentanyl	male, 46 years old	Blood	20.0 ng/mL	–		[76]
Methoxyacetylfentanyl	male, 35 years old	Femoral blood	36.2 ng/mL	Blood: Acrylfentanyl: 2.1 ng/mL (see Table 2) Cocaine: 120 ng/mL Benzoylecgonine: 3500 ng/mL	Acute combined drug overdose (acrylfentanyl and cocaine)	[76]
Methoxyacetylfentanyl	male, 55 years old	Femoral blood	11.2 ng/mL	Blood: Ethanol: 0.52 g/L Alprazolam: 52 ng/mL Hydromorphone: 1.1 ng/mL Oxycodone: 71 ng/mL Oxymorphone: 18 ng/mL		[76]
Methoxyacetylfentanyl	male, 45 years old	Femoral blood	15.1 ng/mL	Blood: Benzoylecgonine: 260 ng/mL Morphine: 7.4 ng/mL Amphetamine: 64 ng/mL Methamphetamine: 870 ng/mL		[76]
Methoxyacetylfentanyl	male, 50 years old	Femoral blood	15.6 ng/mL	Blood: Amphetamine: 74 ng/mL Methamphetamine: 300 ng/mL		[76]
Methoxyacetylfentanyl	male, 33 years old	Femoral blood	21.2 ng/mL	Blood: Benzoylecgonine: 250 ng/mL		[76]
Methoxyacetylfentanyl	male, 29 years old	Femoral blood	14 ng/mL	Alprazolam Quetiapine Gabapentin Duloxetine para-Fluoroisobutyrylfentanyl (FIBF): 27 ng/mL (see Table 2) Cyclopropylfentanyl: 0.10 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 9.7 ng/mL	Pneumonia, secondary to drug intoxication	[94]
		Cardiac blood	70 ng/mL	para-Fluoroisobutyrylfentanyl (FIBF): 31 ng/mL (see Table 2) Cyclopropylfentanyl: 0.15 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): 5.1 ng/mL		
		Urine	positive	para-Fluoroisobutyrylfentanyl (FIBF): positive (see Table 2) Cyclopropylfentanyl: positive (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive p-Fluorofentanyl: positive Isobutyrylfentanyl: positive Butyrfentanyl: positve (see Table 2) Valerylfentanyl: positive		
MT-45		Femoral blood	1.9 μg/g	–	MT-45 intoxication	[99]
MT-45		Femoral blood	0.82 μg/g	Quetiapine: 0.51 μg/g	MT-45 intoxication	[99]

MT-45	Femoral blood	0.46 μg/g	Gabapentin: 27 μg/g Methiopropamine (MPA): 1.3 μg/g (see Table 3) Flubromazepam: 0.43 μg/g (see Table 3) Pyrazolam: positive Ethylphenidate: positive (see Table 3)	Mixed intoxication	[99]
MT-45	Femoral blood	0.008 μg/g	Alprazolam: 0.06 μg/g Gabapentin: 5.5 μg/g Morphine: 0.02 μg/g THC: 0.6 ng/g	Pneumonia and intoxication	[99]
MT-45	Femoral blood	0.38 μg/g	Flubromazepam: 0.16 μg/g (see Table 3) Sertraline: 0.1 μg/g Desmethylsertraline: 0.3 μg/g Pyrazolam: positive	Pneumonia and intoxication	[99]
MT-45	Femoral blood	0.35 μg/g	Mirtazapine: 0.03 μg/g Desmethylmirtazapine: 0.02 μg/g (2-Aminopropyl)-2,3-dihydrobenzofuran (APDB): 0.6 μg/g (see Table 3)	Mixed intoxication	[99]
MT-45	Femoral blood	0.93 μg/g	Fluoxetine: 0.57 μg/g Norfluoxetine: 0.51 μg/g	MT-45 intoxication	[99]
MT-45	Femoral blood	1.0 μg/g	Oxycodone: 0.02 μg/g Flubromazepam: 0.12 μg/g (see Table 3)	MT-45 intoxication	[99]
MT-45	Femoral blood	0.51 μg/g	Flubromazepam: 0.1 μg/g (see Table 3) Sertraline: 0.3 μg/g Desmethylsertraline: 0.6 μg/g Tramadol: 0.79 μg/g	Mixed intoxication	[99]
MT-45	Femoral blood	0.39 μg/g	Gabapentin: 2.3 μg/g Lamotrigine: 1.0 μg/g Amphetamine: 0.08 μg/g Ethanol: positive	Mixed intoxication	[99]
MT-45	Femoral blood	0.27 μg/g	Gabapentin: 4 μg/g Codeine: 0.03 μg/g Methiopropamine (MPA): positive (see Table 3) 2-aminoindane: positive	MT-45 intoxication	[99]
MT-45	Femoral blood	0.16 μg/g	Flubromazepam: 0.09 μg/g (see Table 3) Diclazepam: positive (see Table 3)	Mixed intoxication	[99]
MT-45	Femoral blood	0.19 μg/g	Alimemazine: 0.6 μg/g Fentanyl: 0.0053 μg/g Fluoxetine: 0.3 μg/g Norfluoxetine: 0.24 μg/g Bupropion: 0.05 μg/g Alprazolam: 0.01 μg/g Nordiazepam: 0.04 μg/g	Mixed intoxication (opioids)	[99]
MT-45	Femoral blood	0.09 μg/g	Codeine: 0.61 μg/g Morphine: 0.06 μg/g Hydrocodone: 0.03 μg/g Diazepam: 0.03 μg/g Nordiazepam: 0.10 μg/g Olanzapine: 0.08 μg/g Desmethylolanzapine: 0.05 μg/g Ethanol: positive	Mixed intoxication (ethanol + opioids)	[99]
MT-45	Femoral blood	0.2 μg/g	–	MT-45 intoxication	[99]
MT-45	Femoral blood	0.35 μg/g	Alimemazine: 0.5 μg/g Desmethylalimemazine: 0.5 μg/g Diclazepam: positive (see Table 3)	Mixed intoxication (alimemazine, MT-45 and diclazepam)	[99]
MT-45	Femoral blood	0.15 μg/g	–	Injury	[99]
MT-45	Femoral blood	0.77 μg/g	–	MT-45 intoxication	[99]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
MT-45		Femoral blood	0.46 μg/g	Gabapentin: 5.9 μg/g Diazepam: 0.12 μg/g Alprazolam: 0.008 μg/g Venlafaxine: 1.1 μg/g Desvenlafaxine: 0.4 μg/g Carbamazepine: 3.02 μg/g Alimemazine: 0.06 μg/g Levomepromazine: 0.07 μg/g	MT-45 intoxication	[99]
MT-45		Femoral blood	0.006 μg/g	Fentanyl: 0.023 μg/g Metoclopramide: 0.07 μg/g Mirtazapine: 0.26 μg/g Desmethylmirtazapine: 0.11 μg/g Zopiclone: 0.06 μg/g Gabapentin: 13 μg/g Flubromazepam: positive (see Table 3)		[99]
MT-45		Femoral blood	0.31 μg/g	Duloxetine: 0.07 μg/g Morphine: 0.007 μg/g Ethylmorphine: 0.01 μg/g		[99]
MT-45		Femoral blood	0.14 μg/g	Methadone: 0.38 μg/g Alimemazine: 0.2 μg/g Mirtazapine: 0.09 μg/g Promethazine: 0.5 μg/g Desmethylpromethazine: 0.1 μg/g Diazepam: 0.51 μg/g Nordiazepam: 0.63 μg/g Flubromazepam: 0.14 μg/g (see Table 3) 4'-Fluoro-α-pyrrolidinopentiophenone (4-F-PVP): 0.42 μg/g (see Table 3)	Mixed intoxication	[99]
MT-45		Femoral blood	0.51 μg/g	Propranolol: 0.03 μg/g		[99]
MT-45		Femoral blood	1.5 μg/g	Olanzapine: 0.04 μg/g 1-(benzofuran-6-yl)-N-methylpropan-2-amine (6-MAPB): positive 6-aminopropylbenzofuran (6-APB): positive (see Table 3) N-ethylbuphedrone: positive	Mixed intoxication with opiates and illicit drugs	[99]
MT-45		Femoral blood	0.15 μg/g	Tramadol: 2.1 μg/g Desmethyltramadol: 0.31 μg/g	Intoxication with tramadol and MT-45	[99]
MT-45		Femoral blood	0.05 μg/g	Diazepam: 0.11 μg/g Nordiazepam: 0.23 μg/g Fluoxetine: 1.5 μg/g Norfluoxetine: 0.8 μg/g Pregabalin: 3.1 μg/g Methylphenidate: 0.3 μg/g Ritalinic acid: 0.89 μg/g		[99]
MT-45		Femoral blood	1.7 μg/g	Ethanol: positive		[99]
MT-45		Femoral blood	0.47 μg/g	Lamotrigine: 3.5 μg/g Citalopram: 0.3 μg/g Quetiapine: 0.22 μg/g 7-hydroxyquetiapine: 0.02 μg/g Propranolol: 0.1 μg/g Ethanol: positive		[99]
MT-45	male, 35 years old	Femoral blood	520 ng/mL	Femoral blood: Etizolam: 35 ng/mL (see Table 3) Diphenhydramine: 220 ng/mL Urine, vitreous humor and bile: MT-45: positive	Combined toxicity of MT-45 and etizolam; accidental by unintentional overdose	[100]

MT-45	male, 24 years old	Femoral blood	2900 ng/mL 660 ng/mL (one year later)	Femoral blood and stomach contents: Lidocaine: positive Femoral blood: PB-22: <0.1 ng/mL (see Table 1) 5F-AKB-48 (5F-APINACA): <0.1 ng/mL (see Table 1) Femoral blood, urine and stomach contents: Methoxmetamine: presence indicated (see Table 3)	By exclusion of other causes of death, attributed to consumption of an MT-45 overdose	[46]
		Heart blood	1300 ng/mL			
		Urine	370 ng/mL			
		Liver	24 ng/mg			
		Vitreous humor	260 ng/mL			
		Pericardial fluid	1050 ng/mL			
		Gastric contents	49 μg/mL			
MT-45	male, 32 years old	Femoral blood	0.11 μg/g	Oxycodone: 0.10 μg/g Amphetamine: 0.13 μg/g Flubromazolam: 0.009 μg/g (see Table 3) 3-methoxy-phencyclidine (3-MeO-PCP): 0.06 μg/g (see Table 3) 4-methoxy-phencyclidine (4-MeO-PCP): 0.03 μg/g (see Table 3) THJ-018: positive THC: 0.0011 μg/g	Mixed drug intoxication; accident	[101]
Ocfentanil	female, 30 years old	Peripheral blood	3.7 ng/mL	Ethanol: 200 μg/mL Acetaminophen: 3 μg/mL Caffeine: 0.7 μg/mL Morphine: <5 ng/mL	Asphyxia syndrome likely related to toxic origin	[102]
		Cardiac blood	3.9 ng/mL	Ibuprofen: positive Acetaminophen: positive Caffeine: positive		
		Vitreous humor	2.0 ng/mL	Morphine: 5.2 ng/mL		
		Bile	8.4 ng/mL	Morphine: 69.1 ng/mL Acetaminophen: positive Caffeine: positive		
		Gastric contents	2.5 ng/mL	–		
Ocfentanil	male, 17 years old	Femoral blood (EDTA, external body examination)	15.3 ng/mL	Acetaminophen: 45 μg/mL Caffeine: 0.23 μg/mL	Acute intoxication with ocfentanil; accident	[103]
		Vitreous humor (external body examination)	12.5 ng/mL			
		Cardial blood (EDTA, autopsy)	23.3 ng/mL			
		Cardial blood (without preservative, autopsy)	21.9 ng/mL			
		Urine	6.0 ng/mL	Urine and stomach contents: Acetaminophen: positive Caffeine: positive		
		Stomach contents	17.1 ng/mL or g			
		Liver	31.2 ng/g	Hair (0-6 cm): Cocaine: 0.33 ng/mg Norcocaine: <0.005 ng/mg Benzoylecgonine: 0.14 ng/mg 6-monoacetylmorphine: 0.54 ng/mg Morphine: 1.10 ng/mg Codeine: 0.11 ng/mg		
		Kidney	51.2 ng/g			
		Brain tissue	37.9 ng/g			
		Bile	13.7 ng/g			

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Ocfentanil	male, 24 years old	Femoral blood (fluoride stabilized)	9.1 ng/mL	Peripheral blood: Citalopram: 130 ng/mL Quetiapine: <10 ng/mL THC: 2.8 ng/mL THC-COOH: <5 ng/mL	Acute ocfentanil intoxication	[104]
		Femoral blood (heparin stabilized)	7.5 ng/mL			
		Heart blood	27.9 ng/mL			
		Urine	480 ng/mL			
Ocfentanil		Peripheral blood	3.7 ng/mL	Ethanol: 0.20 g/L Caffeine: 0.7 μg/mL Paracetamol: 3 μg/mL Morphine: <5 ng/mL		[105]
Ocfentanil	female, 37 years old	Peripheral blood	11.6 ng/mL	Paracetamol: <2,5 μg/mL 6-monoacetylmorphine: 4 ng/mL Morphine: 40 ng/mL Codeine: <5 ng/mL		[105]
U-47700	male, 27 years old	Femoral blood	1.46 μg/mL	Postmortem blood: Quetiapine: <0.05 μg/mL Amphetamine: <0.1 μg/mL Naproxen: <0.8 μg/mL Urine: Quetiapine: positive Amphetamine: positive Amitriptyline: positive Mexedrone: positive Ketamine: positive	-	[106]
U-47700	male, 46 years old	Peripheral blood	190 ng/mL	Alprazolam: 0.12 mg/L Nordiazepam: <0.05 mg/L Doxylamine: 0.30 mg/L Diphenhydramine: 0.14 mg/L Ibuprofen: 2.4 mg/L Salicylic acid: <20mg/L THC-COOH: 2.4 ng/mL	Acute U-47700 and alprazolam abuse; accident	[107]
		Central blood	340 ng/mL			
		Liver	1700 ng/g			
		Vitreous humor	170 ng/mL			
		Urine	360 ng/mL			
		Gastric	<1 mg			
U-47700	male, 30 years old	Subclavian blood	13.8 ng/mL	Fentanyl: 10.9 ng/mL Sertraline: 180 ng/mL		[108]
		Urine	71.0 ng/mL	Fentanyl: positive Sertraline: positive		
U-47700	male, 20 years old	Peripheral blood	382 ng/mL	Amphetamine: 12 ng/mL Caffeine: positive		[66]
U-47700	male, 18 years old	Peripheral blood	17 ng/mL	Blood: Ethanol: 0.30 g/L Butyrfentanyl: 26 ng/mL (see Table 2) Urine: Carbamazepine: positive Ibuprofen: positive Iminostilbene: positive Oxcarbazepine: positive Butyrfentanyl: suspected Vitreous: Ethanol: 0.30 mg/L		[66]

U-47700	male, 39 years old	Femoral blood	217 ng/mL	Blood: Mephedrone (4-MMC): 22 ng/mL (see Table 3) Etizolam: positive (see Table 3)	[66]
U-47700	male, 25 years old	Peripheral blood	334 ng/mL	–	[66]
U-47700	male, 23 years old	Peripheral blood	252 ng/mL	Blood: Citalopram: 43 ng/mL Urine: Cotinine: positive Caffeine: positive Nicotine: positive Citalopram: positive	[66]
U-47700	male, 29 years old	Blood	453 ng/mL	Cannabinoids: positive Mitragynine: positive	[66]
U-47700	male, 29 years old	Peripheral blood	242 ng/mL	THC-COOH: 5.3 ng/mL	[66]
U-47700	male, 26 years old	Blood	103 ng/mL	Blood: Diphenhydramine: 694 ng/mL Urine: Diphenhydramine and metabolites: positive 3-methoxy-phencyclidine (3 MeO PCP): positive (see Table 3) Gastric contents: Diphenhydramine and metabolites: positive	[66]
U-47700	male, 21 years old	Aorta blood	299 ng/mL	Blood: Tramadol: <250 ng/mL Alprazolam: 47 ng/mL Lorazepam: 11 ng/mL 3-methoxy-phencyclidine (3-MeO-PCP): 180 ng/mL (see Table 3) Urine: Alprazolam: positive Amphetamine: positive Tramadol: positive	[66]
U-47700	male, 32 years old	Aorta blood	311 ng/mL	Blood: Oxycodone :11 ng/mL Venlafaxine: 2600 ng/mL O-Desmethylvenlafaxine: 380 ng/mL Liver: Venlafaxine: 7.5 mg/kg O-Desmethylvenlafaxine: 0.87 mg/kg	[66]
U-47700	male, 24 years old	Aorta blood	487 ng/mL	Etizolam: 86 ng/mL (see Table 3) Chlorpheniramine: <250 ng/mL Diphenhydramine: 250 ng/mL	[66]
U-47700	male, 24 years old	Aorta blood	59 ng/mL	Furanylfentanyl: positive (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive	[66]
U-47700	male, 36 years old	Aorta blood	135 ng/mL	Furanylfentanyl: 26 ng/mL (see Table 2) Ethanol: positive Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive	[66]
U-47700	male, 33 years old	Aorta blood	167 ng/mL	Furanylfentanyl: 56 ng/mL (see Table 2) Morphine: 48 ng/mL Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive 6-monoacetylmorphine: positive Quinine: positive	[66]
U-47700	male, 29 years old	Aorta blood	490 ng/mL	Furanylfentanyl: 76 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive	[66]

Table 2 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
U-47700	male, 40 years old	Aorta blood	105 ng/mL	Furanylfentanyl: 2.5 ng/mL (see Table 2) Despropionylfentanyl / 4-anilino-N-phenethyl-piperidine (4-ANPP): positive Quinine: positive		[66]
U-47700	male, 24 years old	Femoral blood	approx. 1.52 μg/mL	Femoral blood: Venlafaxine: approx. 1091 ng/mL Desmethylvenlafaxine: approx. 132 ng/mL Trazodone: approx. 45 ng/mL Nordiazepam: positive Caffeine: positive Theophylline: positive Gastric contents: Venlafaxine: positive Trazodone: positive Haloperidol: positive Nordiazepam: positive Caffeine: positive Theophylline: positive	Acute intoxication by U-47700	[109]
		Pericardial fluid (*liquor pericardii*)	0.67 μg/mL	meta-Chlorophenylpiperazine (mCPP): approx. 5.3 ng/mL (probably metabolite of trazodone)		
		Urine	1.35 μg/mL	Oxazepam: positive Temazepam: positive		
U-47700		Femoral blood	525 ng/mL	Unknown matrix: Diphenidine: approx. 1.7 ng/mL (see Table 3) Methoxphenidine: approx. 26 ng/mL (see Table 3) Ibuprofen: approx. 1.8 μg/mL Naloxone: 1.9 ng/mL	U-47700 consumption	[110]
		Heart blood	1347 ng/mL			
		Urine	1393 ng/mL			
		Kidney	2.7 ng/mg			
		Liver	4.3 ng/mg			
		Lung	3.2 ng/mg			
		Brain	0.97 ng/mg			
U-47700		Femoral blood	819 ng/mL	Unknown matrix: Diphenhydramine: approx. 45 ng/mL Methylphenidate: approx. 2.5 ng/mL	U-47700 consumption	[110]
		Heart blood	1043 ng/mL			
		Urine	1848 ng/mL			
		Kidney	1.4 ng/mg			
		Liver	3.1 ng/mg			
		Lung	2.4 ng/mg			
		Brain	1.1 ng/mg			
U-47700	male, 34 years old	Femoral blood	approx. 0.36 μg/mL	Central (aortic) blood: 3-Fluorophenmetrazine: 2.6 μg/mL (see Table 3) Femoral blood: 3-Fluorophenmetrazine (3-FPM): 2.4 μg/mL (see Table 3) Amitriptyline: 440 ng/mL Nortriptyline: 290 ng/mL Methamphetamine: <LOQ (40 ng/mL) Amphetamine: 70 ng/mL Diazepam: 200 ng/mL Nordiazepam: 180 ng/mL Temazepam: 11 ng/mL Flubromazolam: positive (see Table 3) Delorazepam: positive	Multiple drug-toxicity (3-FPM, U-47700, amitriptyline, methamphetamine, diazepam, temazepam, flubromazolam and delorazepam); accident	[111]

				Urine: 3-Fluorophenmetrazine (3-FPM): positive (see Table 3)		
U-47700	N=2	Whole blood	189 ng/mL 547 ng/mL		Drug intoxication, accident	[97] (abstract only)
U-47700	male, 24 years old	Serum (42 min after hospital admission)	370 ng/mL	Flubromazepam: 830 ng/mL (see Table 3) Hydroxyflubromazepam: 160 ng/mL Pregabalin: 1.7 μg/mL Low concentrations of diazepam, nordazepam, desalkylflurazepam and lidocaine were additionally observed in the samples.	Intoxication by the synthetic opioid U-47700 with a contribution of flubromazepam	[112]
		Serum (9 hours after hospital admission)	37 ng/mL	Flubromazepam: 370 ng/mL (see Table 3) Hydroxyflubromazepam: 87 ng/mL Pregabalin: 1.3 μg/mL		
		Serum (24 hours after hospital admission)	6.3 ng/mL	Flubromazepam: 530 ng/mL (see Table 3) Hydroxyflubromazepam: 120 ng/mL Pregabalin: 0.29 μg/mL		
		Serum (33 hours after hospital admission)	2.1 ng/mL	Flubromazepam: 520 ng/mL (see Table 3) Hydroxyflubromazepam: 76 ng/mL Pregabalin: 0.24 μg/mL		
		Serum (41 hours after hospital admission)	2.3 ng/mL	Flubromazepam: 580 ng/mL (see Table 3) Hydroxyflubromazepam: 100 ng/mL Pregabalin: approx. 0.12 μg/mL		
		Urine (41 hours after hospital admission)	2.0 ng/mL	Flubromazepam: 13 ng/mL (see Table 3) Hydroxyflubromazepam: 310 ng/mL Pregabalin: 1.39 μg/mL		
		Serum (57 hours after hospital admission)	2.6 ng/mL	Flubromazepam: 480 ng/mL (see Table 3) Hydroxyflubromazepam: 100 ng/mL Pregabalin: approx. 0.062 μg/mL		
		Serum (81 hours after hospital admission)	4.2 ng/mL	Flubromazepam: 280 ng/mL (see Table 3) Hydroxyflubromazepam: 55 ng/mL Pregabalin: approx. 0.062 μg/mL		
U-47700	male, 26 years old	Heart blood	0.26 mg/L	THC: 19 ng/mL	Acute U-47700 intoxication, accident	[113]
		Femoral blood	0.40 mg/L			
		Vitreous fluid	0.09 mg/L			
		Brain	0.38 mg/kg			
		Liver	0.28 mg/kg			
		Urine	4.6 mg/L			
U-47700	male, 63 years old	Peripheral blood	24 ng/mL	Blood: Ethanol: 0.25 g/L Cyclopropylfentanyl: 31.5 ng/mL (see Table 2) Cocaine: 25 ng/mL Benzoylecgonine: 58 ng/mL		[76]
U-47700	male, 57 years old	Peripheral blood	7.8 ng/mL	Blood: Cyclopropylfentanyl: 18.5 ng/mL (see Table 2) Cocaine: 130 ng/mL Benzoylecgonine: 910 ng/mL Fentanyl: 6.2 ng/mL Norfentanyl: 5.5 ng/mL		[76]

Table 3
Death cases involving "bath salts" and other NPS.

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
25C-NBOMe	N=6 (5 males, 1 female)	Blood	1.5-12.4 ng/mL	4-fluoroamphetamine: 12-604 ng/mL (see Table 3)		[114] (abstract only)
2-fluoromethamphetamine (2-FMA)	male, 23 years old	Peripheral blood	0.041 nmol/mL	AH-7921: 1.3 nmol/mL (see Table 2) 3-methylmethcathinone (3-MMC): 0.012 nmol/mL (see Table 3) Codeine: 1.4 nmol/mL Paracetamol: 124 nmol/mL		[79,80]
2-fluoromethamphetamine (2-FMA)	male	Peripheral blood	0.0069 μg/mL	AH-7921: 0.43 μg/mL (see Table 2) Codeine: 0.42 μg/mL Codeine-6-glucuronide: 0.77 μg/mL Acetaminophen: 19 μg/mL 3-Methylmethcathinone (3-MMC): 0.0021 μg/mL (see Table 3)	Intoxication with AH-7921 in combination with other psychoactive drugs	[84]
3-Fluorophenmetrazine (3-FPM)	male, 54 years old	Peripheral blood	302 ng/mL	Methoxpenidine: 7477 ng/mL (see Table 3) Laudanosine: 1.15 μg/mL Citalopram: 200 ng/mL Midazolam: 60 ng/mL Lidocaine: <1 μg/mL Darunavir : 4.3 μg/mL Fosamprenavir: 30 ng/mL Ritonavir: 60 ng/mL Benzoylecgonine: 119 ng/mL Methylecgonine: 9 ng/mL		[105]
3-Fluorophenmetrazine (3-FPM)	male, 34 years old	Peripheral (femoral) blood	2.4 μg/mL	Femoral blood: U-47700:approx. 0.36 μg/mL (see Table 2) Amitriptyline: 440 ng/mL Nortriptyline: 290 ng/mL Methamphetamine: <LOQ (40 ng/mL) Amphetamine: 70 ng/mL Diazepam: 200 ng/mL Nordiazepam: 180 ng/mL Temazepam: 11 ng/mL Flubromazolam: positive (see Table 3) Delorazepam: positive	Multiple drug-toxicity (3-FPM, U-47700, amitriptyline, methamphetamine, diazepam, temazepam, flubromazolam and delorazepam); accident	[111]
		Central (aortic) blood Urine	2.6 μg/mL positive			
3-methoxy-phencyclidine (3-MeO-PCP)	male, 29 years old	Blood	139 ng/mL	Blood: Diphenhydramine: 4.1 μg/mL Marijuana metabolite: presumptively positive Amphetamine: <100 ng/mL Stomach contents: Diphenhydramine: 8000 ng/mL (total 0.12 mg)	Combined 3-MeO-PCP, diphenhydramine and amphetamine toxicity	[115]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 21 years old	Blood	3.2 μg/mL	Ethanol: 0.47 g/L Bupropion: 1.8 μg/mL Delorazepam: positive Mitragynine: positive Paroxetine: positive	Acute intoxication due to poly-drug consumption; accident	[116]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 58 years old	Blood	0.63 μg/mL	Methamphetamine: 0.11 μg/mL	Acute intoxication due to poly-drug consumption; accident	[116]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 27 years old	Femoral blood	0.38 μg/g	–	3-MeO-PCP intoxication; accident	[101]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 21 years old	Femoral blood	0.18 μg/g	Buprenorphine: 2.2 ng/g Norbuprenorphine: 1.1 ng/g 5-methoxy-N-methyl-N-isopropyltryptamin (5-MeO-MiPT): 0.13 μg/g (see Table 3)	3-MeO-PCP, buprenorphine, 5-MeO-MiPT intoxication; suicide	[101]

3-methoxy-phencyclidine (3-MeO-PCP)	male, 27 years old	Femoral blood	0.23 μg/g	Methadone: 0.44 μg/g Diazepam: 0.53 μg/g Nordazepam: 0.62 μg/g Temazepam: 0.03 μg/g Oxazepam: 0.04 μg/g Pregabalin: 2.7 μg/g Methamphetamine: 0.04 μg/g Buprenorphine: 0.2 ng/g Norbuprenorphine: 0.7 ng/g	Mixed drug intoxication; accident	[101]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 29 years old	Femoral blood	0.12 μg/g	Nordazepam: 0.09 μg/g Pregabalin: 14 μg/g Flubromazolam: 0.01 μg/g (see Table 3) AB-FUBINACA: positive THJ-018: positive Buprenorphine: 2.0 ng/g Norbuprenorphine: 2.3 ng/g Methylphenidate: 0.020 μg/g Ritalinic acid: 0.48 μg/g	Asphyxia; suicide	[101]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 32 years old	Femoral blood	approx. 0.06 μg/g	Oxycodone: 0.10 μg/g Amphetamine: 0.13 μg/g Flubromazolam: 0.009 μg/g (see Table 3) MT-45: 0.11 μg/g (see Table 3) 4-methoxy-phencyclidine (4-MeO-PCP): approx. 0.03 μg/g (see Table 3) THJ-018: positive THC: 0.0011 μg/g	Mixed drug intoxication; accident	[101]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 21 years old	Aorta blood	180 ng/mL	Blood: U-47700: 299 ng/mL (see Table 2) Tramadol: <250 ng/mL Alprazolam: 47 ng/mL Lorazepam: 11 ng/mL Urine: Alprazolam: positive Amphetamine: positive Tramadol: positive		[66]
3-methoxy-phencyclidine (3-MeO-PCP)	male, 27 years old	Femoral blood	0.05 μg/g	Tramadol: 0.06 μg/g Alprazolam: 0.02 μg/g Fentanyl: 25 ng/g Amphetamine: 0.09 μg/g	Fentanyl intoxication; accident	[101]
3-methoxy-phencyclidine (3-MeO-PCP)	female, 20 years old	Femoral blood	0.08 μg/g	Tramadol: 13 μg/g O-desmethyltramadol: 4.9 μg/g	Tramadol/O-desmethyltramadol intoxication; accident	[101]
3-methylmethcathinone (3-MMC)	male, 69 years old	Peripheral blood	330 ng/mL	GHB: 576 ng/mL Pseudoephedrine: 30 ng/mL	Cardiorespiratory arrest	[105]
3-methylmethcathinone (3-MMC)	male, 23 years old	Peripheral blood	0.012 nmol/mL	AH-7921: 1.3 nmol/mL (see Table 2) 2-fluoromethamphetamine (2-FMA): 0.041 nmol/mL (see Table 3) Codeine: 1.4 nmol/mL Paracetamol: 124 nmol/mL		[79,80]
3-methylmethcathinone (3-MMC)	male	Peripheral blood	0.0021 μg/mL	AH-7921: 0.43 μg/mL (see Table 2) Codeine: 0.42 μg/mL Codeine-6-glucuronide: 0.77 μg/mL Acetaminophen: 19 μg/mL 2-fluoromethamphetamine (2-FMA): 0.0069 μg/mL (see Table 3)	Intoxication with AH-7921 in combination with other psychoactive drugs	[84]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
3,4-Dimethylcathinone (3,4-DMMC)	male, 26 years old	Femoral blood	approx. 500 ng/mL	Heliomethylamine: approx. 150 ng/mL (see Table 3)	Acute poisoning by new psychoactive substances	[93]
		Urine	approx. 21700 ng/mL	Heliomethylamine: approx. 10000 ng/mL (see Table 3)		
		Gastric contents	approx. 5000 ng/mL	Heliomethylamine: approx. 14600 ng/mL (see Table 3)		
		Bile fluid	approx. 10 ng/mL	Heliomethylamine: approx. 900 ng/mL (see Table 3)		
		Heart blood	approx. 1500 ng/mL	Heliomethylamine: approx. 1600 ng/mL (see Table 3)		
		Liver	approx. 20 ng/mg	Heliomethylamine: approx. 50 ng/mg (see Table 3)		
4-fluoroamphetamine	N=6 (5 males, 1 female)	Blood	12-604 ng/mL	25C-NBOMe: 1.5-12.4 ng/mL (see Table 3)		[114] (abstract only)
4'-Fluoro-α-pyrrolidinopentiophenone (4-F-PVP)		Femoral blood	0.42 μg/g	Methadone: 0.38 μg/g Alimemazine: 0.2 μg/g Mirtazapine: 0.09 μg/g Promethazine: 0.5 μg/g Desmethylpromethazine: 0.1 μg/g Diazepam: 0.51 μg/g Nordiazepam: 0.63 μg/g Flubromazepam: 0.14 μg/g (see Table 3) MT-45: 0.14 μg/g (see Table 2)	Mixed intoxication	[99]
4-Methoxyphencyclidine (4-MeO-PCP)	male, 54 years old	Peripheral (iliac vein) blood	8.2 μg/mL	4-Hydroxy-*N*-methyl-*N*-ethyltryptamine (4-HO-MET): presumptively identified Venlafaxine: 0.51 μg/mL Olanzapine: 0.42 μg/mL Lorazepam: <0.05 μg/mL Hydroxyzine: positive	Acute mixed drug intoxication; accident	[117]
		Central blood	14 μg/mL			
		Liver	120 μg/g			
		Vitreous humor	5.1 μg/mL			
		Urine	140 μg/mL			
		Gastric contents	280 mg			
4-Methoxyphencyclidine (4-MeO-PCP)	male, 32 years old	Femoral blood	approx.0.03 μg/g	Oxycodone: 0.10 μg/g Amphetamine: 0.13 μg/g Flubromazolam: 0.009 μg/g MT-45: 0.11 μg/g (see Table 2) 3-methoxy-phencyclidine (3-MeO-PCP): approx. 0.06 μg/g (see Table 3) THJ-018: positive THC: 0.0011 μg/g	Mixed drug intoxication; accident	[101]
4-methoxy PV8	male	Femoral blood	389 ng/mL	Femoral blood: Acetylfentanyl: 153 ng/mL (see Table 2) Unknown matrix: 7-aminonitrazepam: 0.20 μg/mL Phenobarbital: 7.70 μg/mL Methylphenidate: 0.03 μg/mL) Chlorpromazine: positive Risperidone: positive	Acute poisoning by “bath salts” containing acetyl fentanyl and 4-methoxy PV8	[71]
		Heart blood	960 ng/mL	Acetylfentanyl: 239 ng/mL (see Table 2)		
		Urine	245 ng/mL	Acetylfentanyl: 240 ng/mL (see Table 2)		
		Gastric contents	500 ng/mL	Acetylfentanyl: 880 ng/mL (see Table 2)		

4-methoxy PV8	female	Femoral blood	2.69 μg/mL	Femoral blood: PV9: 0.743 μg/mL(see Table 3) 4-methoxy PV9: 0.261 μg/mL(see Table 3) Diphenidine: 1.38 μg/mL(see Table 3) Ethanol: 1.52 mg/mL Presence of triazolam, flunitrazepam, nitrazepam and their metabolites	4-methoxy PV8, PV9, 4-methoxy PV9 and diphenidine poisoning under the influence of three benzodiazepines and alcohol	[118] (abstract only)
4-methylamphetamine (4-MA)	N=6	Blood	0.58 μg/mL 1.50 μg/mL 2.60 μg/mL 3.49 μg/mL 3.77 μg/mL 5.80 μg/mL		Drugs death	[82]
4-methylamphetamine (4-MA)	N=1	Blood	0.07 μg/mL		Alternative, not drug related, cause of death	[82]
4-methylethcathinone (4-MEC)		Peripheral blood	0.25 ng/mL	Mephedrone (4-MMC): 0.11 ng/mL (see Table 3) Pentedrone: 0.22 ng/mL (see Table 3) Paracetamol: 5.4 ng/mL Pheniramine: 0.43 ng/mL Bromazepam: 0.04 ng/mL Benzoylecgonine: 150 ng/mL Methylecgonine: 54 ng/mL GHB: 519 ng/mL		[105]
4-methylethcathinone (4-MEC)	male, 22 years old	Femoral blood	0.167 μg/mL	Femoral blood: Ethanol: 0.30 g/L Paracetamol: 5 μg/mL Urine: Ethanol: 0.27 g/L 4-methylethcathinone (4-MEC): positive Paracetamol: positive	4-MEC toxicity	[119]
4-methylethcathinone (4-MEC)	male, 54 years old	Femoral blood	1.73 μg/mL	Femoral blood: Ethanol: 2.29 g/L Propranolol: 0.036 μg/mL Venlafaxine: 0.284 μg/mL O-desmethylvenlafaxine: 0.205 μg/mL Diazepam: <0.005 μg/mL Nordiazepam: 0.033 μg/mL Urine: 4-MEC: positive Ethanol: positive Venlafaxine: positive O-desmethylvenlafaxine: positive	Asphyxiation	[119]
4-methylethcathinone (4-MEC)	male, 36 years old	Peripheral blood	14.6 μg/mL	Hydroxyzine: 160 ng/mL	4-MEC overdose	[120]
4-methylethcathinone (4-MEC)	N=4	Blood	0.46 μg/mL 2.50 μg/mL 5.83 μg/L 17.3 μg/mL		Drugs death	[82]
4-methylethcathinone (4-MEC)	N=2	Blood	0.28 μg/mL 5.03 μg/mL		Alternative, not drug related, cause of death	[82]
4-methylethcathinone (4-MEC)	male, 30 years old	Blood	152 ng/mL	Ethanol: 1.2 ‰	Fatal vehicular collision	[121]
		Urine	122 ng/mL	Ethanol: 1.9 ‰		

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
4-methylethcathinone (4-MEC)	male	Blood	56 ng/mL	para-methoxyamphetamine (PMA): 2347 ng/mL (see Table 3) para-methoxymethylamphetamine (PMMA): 30 ng/mL (see Table 3) Amphetamine: 378 ng/mL Methamphetamine: 48 ng/mL THC: 1.3 ng/mL THC-COOH: 8.7 ng/mL	Overdose of para-methoxyamphetamine (PMA), multiple-drug toxicity	[121]
		Urine	14.3 μg/mL	para-methoxyamphetamine (PMA): 50.1 μg/mL (see Table 3) para-methoxymethylamphetamine (PMMA): 1.7 μg/mL (see Table 3) Amphetamine: positive THC-COOH: 54.7 ng/mL		
		Stomach contents	positive	para-methoxyamphetamine (PMA) : positive (see Table 3) para-methoxymethylamphetamine (PMMA): positive (see Table 3)		
4-methylethcathinone (4-MEC)	male, 36 years old	Femoral blood	1200 ng/mL	Amphetamine: 230 ng/mL	Acute circulatory and respiratory failure resulting from complex poisoning with the cathinone derivative 4-methylethcathinone (4-MEC)	[122]
5-(2-aminopropyl) benzofuran (5-APB)	male, 20 years old	Peripheral (iliac vein blood)	2.5 μg/mL	Ethanol: 0.02 % w/v	Acute 5-APB intoxication; accident	[123]
		Central blood	2.9 μg/mL			
		Liver	16 μg/g			
		Vitreous humor	1.3 μg/mL			
		Urine	23 μg/mL			
		Gastric contents	6 mg			
5-(2-aminopropyl) benzofuran (5-APB)	male, 39 years old	Peripheral blood	4970 ng/mL	Methiopropamine (MPA): 1041 ng/mL (see Table 3) Methylphenidate: 44 ng/mL MDPV metabolite: positive Aripiprazole: 80 ng/mL Mirtazapine: 80 ng/mL Tropatepine: 130 ng/mL Oxazepam: 120 ng/mL		[105]
5-(2-aminopropyl) benzofuran (5-APB)	male, 39 years old	Peripheral blood	129 ng/mL	5-(2-methylaminopropyl) benzofuran (5-MAPB): 2880 ng/mL (see Table 3) THC: 10 ng/mL 11-OH-THC: 5.3 ng/mL THC-COOH: 33 ng/mL		[105]
5- and 6-aminopropylbenzofuran (5- and 6-APB)	N=10	Blood	0.11 μg/mL 0.14 μg/mL 0.14 μg/mL 0.15 μg/mL 0.40 μg/mL 1.43 μg/mL 3.87 μg/mL 1.48 μg/mL 1.60 μg/mL 4.19 μg/mL		Drugs death	[82]
5- and 6-aminopropylbenzofuran (5- and 6-APB)	male	Femoral blood	1.41 μg/mL	Methiopropamine (MPA): 0.051 μg/mL (see Table 3) Ethylphenidate: 0.03 μg/mL (see Table 3)	Mixed drug toxicity	[124]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 23 years old	Femoral blood	18.6 μg/g	Femoral blood: AM-2201: 0.0002 μg/g (see Table 1) Urine: 4-(2-aminopropyl) benzofuran (4-APB)	Intoxication by 5-IT and 4-APB; accident	[53]

5-(2-aminopropyl) indole (5-IT or 5-API)	male, 31 years old	Femoral blood	2.3 μg/g	Hydroxyzine: 0.05 μg/g Etizolam: 0.04 μg/g (see Table 3)	Intoxication by 5-IT and etizolam; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 24 years old	Femoral blood	2.4 μg/g	Zopiclone: 0.03 μg/g Ethylphenidate: 0.003 μg/g (see Table 3) Ritalinic acid: 0.03 μg/g	Undetermined	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 28 years old	Femoral blood	3.8 μg/g	Levetiracetam: 26 μg/g	Epilepsy; natural death	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 20 years old	Femoral blood	1.1 μg/g	Benzoylecgonine: 0.02 μg/g THC: 0.002 μg/g Pentedrone: positive (see Table 3)	Sudden cardiac death and drug intake	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 31 years old	Femoral blood	5.2 μg/g	7-Aminoclonazepam: 0.04 μg/g Perphenazine: 0.01 μg/g Ethylphenidate: 0.12 μg/g (see Table 3) Ritalinic acid: 2.6 μg/g Methylphenidate: 0.0002 μg/g	Intoxication by 5-IT and ethylphenidate; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 33 years old	Femoral blood	4.2 μg/g	–	Probable intoxication by 5-IT	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 31 years old	Femoral blood	1.6 μg/g	Alimemazine: 0.2 μg/g Desmethylalimemazine: 0.1 μg/g Ethylphenidate: 0.18 μg/g (see Table 3) Ritalinic acid: 1.9 μg/g	Intoxication by 5-IT and ethylphenidate; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 29 years old	Femoral blood	0.7 μg/g	Pregabalin: 9.2 μg/g (pleural effusions)	Intoxication by 5-IT and pregabalin	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 28 years old	Femoral blood	2.5 μg/g	Carisoprodol: 0.9 μg/g Meprobamate: positive 7-Aminoclonazepam: 0.32 μg/g	Intoxication by 5-IT	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 55 years old	Femoral blood	2.1 μg/g	Sertraline: 0.7 μg/g Desmethylsertraline: 2.5 μg/g Venlafaxine: 1.0 μg/g O-desmethylvenlafaxine: 0.5 μg/g	Intoxication by 5-IT; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 30 years old	Femoral blood	2.1 μg/g	Methylphenidate: 0.004 μg/g Ritalinic acid: 0.54 μg/g	Probable intoxication by 5-IT; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 40 years old	Femoral blood	1.0 μg/g	–	Intoxication by 5-IT; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 24 years old	Femoral blood	1.1 μg/g	Benzoylecgonine: 0.02 μg/g MDMA: 0.53 μg/g MDA: 0.03 μg/g	Intoxication by 5-IT, MDA, MDMA and cocaine; accident	[53]
5-(2-aminopropyl) indole (5-IT or 5-API)	male, 28 years old	Femoral blood	1.7 μg/g	Ethylphenidate: 0.008 μg/g (see Table 3)	Undetermined	[53]
5-(2-methylaminopropyl) benzofuran (5-MAPB)	male, 39 years old	Peripheral blood	2880 ng/mL	5-(2-aminopropyl) benzofuran (5-APB): 129 ng/mL (see Table 3) THC: 10 ng/mL 11-OH-THC: 5.3 ng/mL THC-COOH: 33 ng/mL		[105]
5-methoxy-N-methyl-N-isopropyltryptamin (5-MeO-MiPT)	male, 21 years old	Femoral blood	0.13 μg/g	Buprenorphine: 2.2 ng/g Norbuprenorphine: 1.1 ng/g 3-methoxy-phencyclidine (3-MeO-PCP): 0.18 μg/g (see Table 3)	3-MeO-PCP, buprenorphine, 5-MeO-MiPT intoxication; suicide	[101]
APDB ((2-Aminopropyl)-2,3-dihydrobenzofuran)		Femoral blood	0.6 μg/g	Mirtazapine: 0.03 μg/g Desmethylmirtazapine: 0.02 μg/g MT-45: 0.35 μg/g (see Table 2)	Mixed intoxication	[99]
Butylone	N=2	Blood	<0.125 μg/mL 1.72 μg/mL		Drugs death	[82]
Butylone	female, 24 years old	Urine	positive	Methylone (see Table 3)	Serotonin syndrome secondary to methylone and butylone	[125]
Butylone	N=16 N=9	Blood Urine	0.01-129 μg/mL 0.24-170 μg/mL			[126]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Diclazepam		Peripheral blood	33.5 ng/mL	Lorazepam: 0.7 ng/mL Lormetazepam: 0.7 ng/mL Anastrozole: positive Paracetamol: 6.9 μg/mL Alprazolam: 15.8 ng/mL Hydroxyalprazolam : <0.5 ng/mL Citalopram: 971 ng/mL Promethazine: 59 ng/mL Codeine: 2092 ng/mL Morphine (free): 187 ng/mL Dihydrocodeine: 14.8 ng/mL		[105]
Diphenidine	male, 30 years old	Femoral vein blood	715 ng/mL	AB-CHMINACA (see Table 1) 5F-AMB (see Table 1)	Poisoning by multiple drugs	[43]
		Right heart blood	707 ng/mL			
		Left heart blood	923 ng/mL			
		Urine	376 ng/mL			
		Brain	1550 ng/g			
		Heart muscle	2070 ng/g			
		Lung	1600 ng/g			
		Liver	2960 ng/g			
		Spleen	1300 ng/g			
		Kidney	2510 ng/g			
		Pancreas	1910 ng/g			
		Adipose tissue	11100 ng/g			
Diphenidine	male, 53 years old	Blood	12 ng/mL	5F-ADB: 0.19 ng/mL (see Table 1)	-	[39]
Diphenidine	female	Femoral blood	1.38 μg/mL	Femoral blood: PV9: 0.743 μg/mL(see Table 3) 4-methoxy PV8: 2.69 μg/mL(see Table 3) 4-methoxy PV9: 0.261 μg/mL(see Table 3) Ethanol: 1.52 g/L Presence of triazolam, flunitrazepam, nitrazepam and their metabolites	4-methoxy PV8, PV9, 4-methoxy PV9 and diphenidine poisoning under the influence of three benzodiazepines and alcohol	[118] (abstract only)
EAPB (Ethylaminopropylbenzofuran)	male, 28 years old	Blood	6.45 μg/mL	MDAI (5,6-methylenedioxy-2-aminoindane): 2.09 μg/mL (see Table 3) Methylaminopropylbenzofuran (MAPB): 0.089 μg/mL Aminopropylbenzofuran (APB, EAPB metabolite): 0.546 μg/mL		[127] (abstract only)
		Urine	14.8 μg/mL	MDAI (5,6-methylenedioxy-2-aminoindane): 69.4 μg/mL (see Table 3) Methylaminopropylbenzofuran (MAPB): 1.0 μg/mL Aminopropylbenzofuran (APB, EAPB metabolite): 4.88 μg/mL Oxazepam		
Ephedrone (methcathinone)	male, 29 years old	Femoral blood	210 ng/mL	Mephedrone (4-methylmethcathinone, 4-MMC): 1300 ng/mL (see Table 3) Ethanol: 2.80 ‰	Acute circulatory and respiratory failure resulting from complex intoxication with cathinone derivatives, including mephedrone and methcathinone (in an alcohol-addicted man who was under the influence)	[122]

Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 23 years old	Inferior vena cava blood	<25 ng/mL	Blood: Alprazolam: 29 ng/mL Urine: Ethylone: positive α-Hydroxyalprazolam: positive THC-COOH: positive Cocaine: positive Benzoylecgonine: positive Levamisole: positive α-PVP: positive (seeTable 3)	Gunshot wound of chest	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 29 years old	Right iliac vein blood	2572 ng/mL	Blood: Ethanol: 0.44 g/L Urine: Ethylone: positive Ethanol: 0.72 g/L THC-COOH: positive Vitreous humor: Ethanol: 0.60 g/L	Multiple gunshot wounds	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 18 years old	Left iliac vein blood	1837 ng/mL	Bile: Ethylone: positive Urine: THC-COOH: positive Urine quantity for ethylone analysis not sufficient	Gunshot wound of chest	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 27 years old	Peripheral blood	38 ng/mL	Blood: Diphenhydramine: <0.5 μg/mL Tramadol: <0.5 μg/mL Urine: Ethylone: positive Acetone: 185 mg/dL THC-COOH: positive Diphenhydramine: positive Tramadol: positive N-desmethyltramadol: positive	Undetermined	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 24 years old	Heart blood	173 ng/mL	Blood: Ethanol: 0.29 g/L Bile: Ethylone: positive Ethanol: 0.34 g/L Vitreous humor: Ethanol: 0.60 g/L Urine quantity for ethylone analysis not sufficient	Blunt impact to head and torso; contributing ethylone and ethanol intoxication	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 24 years old	Inferior vena cava blood	1617 ng/mL	Urine: Ethylone: positive Ethanol: 0.33 g/L THC-COOH: positive	Hanging	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 32 years old	Cavity fluid	1725 ng/mL	Blood: Ethanol: 3.33 g/L Doxylamine: positive Urine: Ethylone: positive Ethanol: 2.45 g/L Doxylamine: positive Vitreous humor: Ethanol: 2.44 g/L	Blunt force head trauma; contributing ethylone and ethanol intoxication	[128]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 23 years old	Peripheral blood	468 ng/mL	Blood: Ethanol: 1.28 g/L Urine: Ethylone: positive Ethanol: 1.51 g/L THC-COOH: positive	Perforation of the left subclavian artery and vein and left common carotid due to gunshot wound of torso and neck	[128]
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	male, 30 years old	Peripheral blood (left common iliac vein)	0.39 μg/mL	Morphine: 0.05 μg/mL Alprazolam: <0.05 μg/mL THC: <1 ng/mL, THC-COOH: 3.6 ng/mL Naproxen: <5 μg/mL	Mixed ethylone, heroin and alprazolam intoxication; accident	[129]
		Central blood (intrapericardial inferior vena cava)	0.38 μg/mL			
		Liver	1.4 μg/g			
		Vitreous humor	0.58 μg/mL			
		Urine	20 μg/mL	6-monoacetylmorphine: positive Codeine: positive Sildenafil: positive 3,4-methylenedioxycathinone: presumptively positive		
		Gastric contents	12 mg			
Ethylone (3,4-methylenedioxy-N-ethylcathinone)		Central blood	0.04 μg/mL		Acute mixed drug intoxication of heroin together with citalopram, alprazolam and dextromethorphan	[129]
		Urine	3.0 μg/mL			
Ethylone (3,4-methylenedioxy-N-ethylcathinone)	N=74	Blood	0.03-91.52 μg/mL			[126]
	N=47	Urine	0.34-2097 μg/mL			
	N=7	Gastric contents	0.08-2.68 μg/mL			
N-ethylpentylone	male, 38 years old	Blood	170 ng/mL			[130] (abstract only)
Ethylphenidate	male, 24 years old	Femoral blood	0.003 μg/g	Zopiclone: 0.03 μg/g 5-(2-aminopropyl) indole (5-IT or 5-API): 2.4 μg/g (see Table 3) Ritalinic acid: 0.03 μg/g	Undetermined	[53]
Ethylphenidate	male, 31 years old	Femoral blood	0.12 μg/g	5-(2-aminopropyl) indole (5-IT or 5-API): 5.2 μg/g (see Table 3) 7-Aminoclonazepam: 0.04 μg/g Perphenazine: 0.01 μg/g Ritalinic acid: 2.6 μg/g Methylphenidate: 0.0002 μg/g	Intoxication by 5-IT and ethylphenidate; accident	[53]
Ethylphenidate	male, 31 years old	Femoral blood	0.18 μg/g	5-(2-aminopropyl) indole (5-IT or 5-API): 1.6 μg/g (see Table 3) Alimemazine: 0.2 μg/g Desmethylalimemazine: 0.1 μg/g Ritalinic acid: 1.9 μg/g	Intoxication by 5-IT and ethylphenidate; accident	[53]
Ethylphenidate	male, 28 years old	Femoral blood	0.008 μg/g	5-(2-aminopropyl) indole (5-IT or 5-API): 1.7 μg/g (see Table 3)	Undetermined	[53]

Ethylphenidate	male, 32 years old	Femoral blood	110 ng/mL	Methadone: 47 ng/mL EDDP: 40 ng/mL Morphine: 5.3 ng/mL Fentanyl: 0.4 ng/mL Methylphenidate: <1 ng/mL Ritalinic acid: 2140 ng/mL	Endocarditis in combination with pneumonia	[131]
		Liver	180 ng/g	Hair: Ethylphenidate: positive		
		Pericardial fluid	130 ng/mL			
		Urine	980 ng/mL	Methadone: positive EDDP: positive Morphine: positive Fentanyl: positive Methylphenidate: positive Ritalinic acid: positive		
		Stomach contents	20.7 ng/mL	Methadone: positive EDDP: positive Morphine: positive Ritalinic acid: positive		
Ethylphenidate	male, 38 years old	Femoral blood	23 ng/mL	Femoral blood: Fentanyl: 4.1 ng/mL Norfentanyl: 0.8 ng/mL Pregabalin: 8440 ng/mL Ritalinic acid: 943 ng/mL Urine: Fentanyl: positive Pregabalin: positive Ritalinic acid: positive Stomach contents: Fentanyl: positive Pregabalin: positive Ritalinic acid: positive	Aspiration of stomach contents, probably under clouding of consciousness caused by drugs (fentanyl and pregabalin)	[131]
Ethylphenidate	male	Femoral blood	2.18 μg/mL	–	Ethylphenidate toxicity	[124]
Ethylphenidate	male	Femoral blood	1.37 μg/mL	Benzoylecgonine: 0.012 μg/mL Sertraline: 0.295 μg/mL Diphenhydramine: 0.043 μg/mL	Hanging	[124]
Ethylphenidate	male	Femoral blood	0.87 μg/mL	Dothiepin: 0.017 μg/mL Methiopropamine (MPA): 4.640 μg/mL (see Table 3) Ethanol: 0.74 g/L	Hanging	[124]
Ethylphenidate	male	Femoral blood	0.11 μg/mL	Methadone: 0.807 μg/mL EDDP: 0.532 μg/mL Zopiclone: 0.123 μg/mL Sertraline: 0.494 μg/mL Aripiprazole: 0.073 μg/mL Dehydroaripiprazole: 0.016 μg/mL 2-aminoindane: 0.101 μg/mL Ethanol: 0.30 g/L	Methadone toxicity and 2-aminoindane toxicity	[124]
Ethylphenidate	male	Femoral blood	0.14 μg/mL	Morphine (free): 0.117 μg/mL Morphine (total): 0.180 μg/mL Codeine (free): 0.011 μg/mL Ketamine: 0.518 μg/mL Cocaine: 0.12 μg/mL Benzoylecgonine: 0.272 μg/mL Venlafaxine: 0.344 μg/mL O-desmethylvenlafaxine: 0.374 μg/mL	Heroin toxicity	[124]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Ethylphenidate	male	Femoral blood	0.03 μg/mL	Methiopropamine (MPA): 0.051 μg/mL (see Table 3) 5- and 6-aminopropylbenzofuran (5-APB/6-APB): 1.410 μg/mL (see Table 3)	Mixed drug toxicity	[124]
Ethylphenidate	male	Femoral blood	0.11 μg/mL	Diazepam: 0.316 μg/mL Nordiazepam: 0.409 μg/mL Temazepam: 0.017 μg/mL Oxazepam: 0.009 μg/mL Morphine (free): 0.071 μg/mL Morphine (total): 0.101 μg/mL Codeine (free): 0.014 μg/mL	Multiple drug toxicity	[124]
Ethylphenidate	male, 38 years old	Femoral blood	>2.0 μg/mL	Femoral blood: Tramadol: positive Paracetamol: positive Morphine: positive Urine: 6-monoacetylmorphine: positive Acetone: positive	A complication of his chronic intravenous drug abuse, namely acute hemorrhage related to a left groin abscess	[132]
Ethylphenidate	female, 33 years old	Femoral blood	1.9 μg/mL	Methadone: positive Procyclidine: positive Propranolol: positive Morphine and metabolites: positive Diazepam: positive Temazepam and metabolites: positive Cannabis metabolite: positive Pregabalin: positive Methylthienylpropamine: positive	Multi-drug toxicity and acute pyelonephritis	[132]
Ethylphenidate	female, 31 years old	Femoral blood	1.2 μg/mL	Femoral blood: Alcohol: positive Morphine and metabolites: positive Cardiac blood: Diazepam and metabolites: positive	Multiple drug toxicity	[132]
Ethylphenidate	male, 27 years old	Femoral blood	0.76 μg/mL	Alcohol: positive Diazepam and metabolite: positive Methylthienylpropamine: positive	Unascertained	[132]
Ethylphenidate	male, 37 years old	Femoral blood	0.61 μg/mL	Diazepam and metabolite: positive Mirtazapine: positive	Empyema, potential contribution by chronic substance misuse	[132]
Ethylphenidate	female, 31 years old	Femoral blood	0.47 μg/mL	Lidocaine: positive Methadone: positive Mirtazapine: positive Promethazine: positive	Bronchopneumonia, chronic drug abuse as possible reason, potential contribution by methadone and ethylphenidate intoxication	[132]
Ethylphenidate	male, 34 years old	Femoral blood	0.41 μg/mL	Alcohol: positive Methadone: positive Diazepam and metabolite: positive Cannabis metabolite: positive	Multiple injuries, presumed fall from height following contact with an electrical cable	[132]
Ethylphenidate	male, 38 years old	Femoral blood	0.35 μg/mL	α-methyltryptamine: positive Etizolam: positive (see Table 3) Diphenhydramine: positive	A-methyltryptamine and ethylphenidate intoxication	[132]
Ethylphenidate	male, 20 years old	Femoral blood	0.32 μg/mL	Fluoxetine and metabolite: positive Pregabalin: positive Zuclopenthixol: positive Morphine and metabolite: positive s Etizolam: positive (see Table 3) Pyrazolam: positive Methoxphenidine: positive (see Table 3)	Ethylphenidate, methoxyphenidine, morphine, pyrazolam and etizolam intoxication	[132]

Ethylphenidate	male, 40 years old	Femoral blood	0.25 μg/mL	Methadone: positive Olanzapine: positive Diazepam and metabolite: positive Cannabis metabolite: positive Fluoxetine and metabolite: positive Methylethcathinone: positive	Multi-drug toxicity, possible contribution by coronary artery atherosclerosis	[132]
Ethylphenidate	male, 35 years old	Femoral blood	0.14 μg/mL	Methadone: positive	Unascertained (probable drug related death)	[132]
Ethylphenidate	female, 33 years old	Antemortem blood	0.46 μg/mL	Dihydrocodeine: positive Hydrocodone: positive Morphine: positive	Sepsis/multiple organ failure, bronchopneumonia, possible contribution by chronic intravenous drug use and chest trauma following a reported fall	[132]
		Femoral blood	0.13 μg/mL	Desmethyldiazepam: positive Ketamine: positive Morphine: positive Paracetamol: positive Alfentanil: positive		[132]
Ethylphenidate	male, 54 years old	Heart blood	0.041 μg/mL	Dihydrocodeine: positive	Unascertained	[132]
Ethylphenidate	male, 45 years old	Femoral blood	0.040 μg/mL	Femoral blood: Diazepam and metabolite: positive Methadone: positive Morphine and metabolites: positive Urine: 6-monoacetylmorphine: positive	Methadone and heroin intoxication	[132]
Ethylphenidate	male, 44 years old	Femoral blood	0.028 μg/mL	Methadone: positive Diazepam and metabolites: positive	Pneumonia and methadone toxicity, possible contribution by cachexia	[132]
Ethylphenidate	male, 42 years old	Femoral blood	0.015 μg/mL	Alcohol: positive Dihydrocodeine: positive Morphine and metabolites: positive Diazepam and metabolite: positive	Head injury, fall from height	[132]
Ethylphenidate	female, 46 years old	Femoral blood	0.010 μg/mL	Beta-hydroxybutyrate: positive Mirtazapine: positive Codeine: positive Morphine: positive Diazepam and metabolite: positive Fluoxetine and metabolite: positive Paracetamol: positive	Disseminated staphylococcus pyogenes (group A) infection, drug use (heroin and ethylphenidate) as possible reason	[132]
Ethylphenidate	male, 25 years old	Femoral blood	0.010 μg/mL	Diazepam and metabolite: positive Paracetamol: positive Codeine and metabolites: positive Morphine and metabolites (6-monoacetylmorphine in blood and urine): positive Mirtazapine: positive	Heroin and codeine toxicity and acute liver failure	[132]
Ethylphenidate	male, 45 years old	Antemortem blood	0.030 μg/mL		Intracerebellar hematoma, ethylphenidate toxicity	[132]
		Antemortem serum	0.008 μg/mL			
		Femoral blood	0.008 μg/mL	Femoral blood: Alcohol: positive Morphine and metabolites: positive Paracetamol: positive Methadone: positive Desmethyldiazepam: positive Urine: 6-monocetylmorphine: positive		

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Etizolam*	Female	Peripheral blood	0.27 μg/mL	AH-7921: 0.33 μg/mL (see Table 2) Methoxetamine: 64 ng/mL (see Table 3) Phenazepam: 1.33 μg/mL 7-aminonitrazepam: 0.043 μg/mL Diazepam: 0.046 μg/mL Nordiazepam: 0.073 μg/mL Oxazepam: 0.018 μg/mL	Intoxication with AH-7921 in combination with several benzodiazepines and methoxetamine	[84]
Etizolam*	male, 35 years old	Femoral blood	35 ng/mL	Femoral blood: MT-45: 520 ng/mL (see Table 2) Diphenhydramine: 220 ng/mL Urine, vitreous humor and bile: MT-45: positive (see Table 2)	Combined toxicity of MT-45 and etizolam; accidental by unintentional overdose	[100]
Etizolam*	male, 24 years old	Aorta blood	86 ng/mL	U-47700: 487 ng/mL (see Table 2) Chlorpheniramine: <250 ng/mL Diphenhydramine: 250 ng/mL		[66]
Etizolam*	female, 59 years old	Blood	263.7 ng/mL	α-hydroxyetizolam: 7.2 ng/mL 8-hydroxyetizolam:11.5 ng/mL	Drowning; suicide	[133]
Etizolam*	male, 49 years old	Blood	25.8 ng/mL	α-hydroxyetizolam: 9.4 ng/mL 8-hydroxyetizolam: 9.3 ng/mL	Autopsy not performed; death from cirrhosis was suspected from medical record and external surface view	[133]
Etizolam*	male, 31 years old	Femoral blood	0.04 μg/g	5-(2-aminopropyl) indole (5-IT or 5-API): 2.3 μg/g (see Table 3) Hydroxyzine: 0.05 μg/g	Intoxication by 5-IT and etizolam; accident	[53]
Etizolam*	N=473	Femoral blood	<0.005-0.95 μg/mL			[134] (abstract only)
Flephedrone (4-Fluoromethcathinon, 4-FMC)	N=2	Blood	0.55 μg/mL 4.42 μg/mL		Drugs death	[82]
Flephedrone (4-Fluoromethcathinon, 4-FMC)	N=1	Blood	0.21 μg/mL		Alternative, not drug related, death	[82]
Flubromazepam		Femoral blood	0.43 μg/g	MT-45: 0.46 μg/g (see Table 2) Gabapentin: 27 μg/g Methiopropamine (MPA): 1.3 μg/g (see Table 3) Pyrazolam: positive Ethylphenidate: positive (see Table 3)	Mixed intoxication	[99]
Flubromazepam		Femoral blood	0.16 μg/g	MT-45: 0.38 μg/g (see Table 2) Sertraline: 0.1 μg/g Desmethylsertraline: 0.3 μg/g Pyrazolam: positive	Pneumonia and intoxication	[99]
Flubromazepam		Femoral blood	0.12 μg/g	Oxycodone: 0.02 μg/g MT-45: 1.0 μg/g (see Table 2)	MT-45 intoxication	[99]
Flubromazepam		Femoral blood	0.1 μg/g	MT-45: 0.51 μg/g (see Table 2) Sertraline: 0.3 μg/g Desmethylsertraline: 0.6 μg/g Tramadol: 0.79 μg/g	Mixed intoxication	[99]
Flubromazepam		Femoral blood	0.09 μg/g	MT-45: 0.16 μg/g (see Table 2) Diclazepam: positive (see Table 3)	Mixed intoxication	[99]

Flubromazepam		Femoral blood	0.14 μg/g	Methadone: 0.38 μg/g Alimemazine: 0.2 μg/g Mirtazapine: 0.09 μg/g Promethazine: 0.5 μg/g Desmethylpromethazine: 0.1 μg/g Diazepam: 0.51 μg/g Nordiazepam: 0.63 μg/g MT-45: 0.14 μg/g (see Table 2) 4'-Fluoro-α-pyrrolidinopentiophenone (4-F-PVP): 0.42 μg/g (see Table 3)	Mixed intoxication	[99]
Flubromazepam	male, 24 years old	Serum (42 min after hospital admission)	830 ng/mL	U-47700: 370 ng/mL (see Table 2) Hydroxyflubromazepam: 160 ng/mL Pregabalin: 1.7 μg/mL Low concentrations of diazepam, nordazepam, desalkylflurazepam and lidocaine were additionally observed in the samples.	Intoxication by the synthetic opioid U-47700 with a contribution of flubromazepam	[112]
		Serum (9 hours after hospital admission)	370 ng/mL	U-47700: 37 ng/mL (see Table 2) Hydroxyflubromazepam: 87 ng/mL Pregabalin: 1.3 μg/mL		
		Serum (24 hours after hospital admission)	530 ng/mL	U-47700: 6.3 ng/mL (see Table 2) Hydroxyflubromazepam: 120 ng/mL Pregabalin: 0.29 μg/mL		
		Serum (33 hours after hospital admission)	520 ng/mL	U-47700: 2.1 ng/mL (see Table 2) Hydroxyflubromazepam: 76 ng/mL Pregabalin: 0.24 μg/mL		
		Serum (41 hours after hospital admission)	580 ng/mL	U-47700: 2.3 ng/mL (see Table 2) Hydroxyflubromazepam: 100 ng/mL Pregabalin: approx. 0.12 μg/mL		
		Urine (41 hours after hospital admission)	13 ng/mL	U-47700: 2.0 ng/mL (see Table 2) Hydroxyflubromazepam: 310 ng/mL Pregabalin: 1.39 μg/mL		
		Serum (57 hours after hospital admission)	480 ng/mL	U-47700: 2.6 ng/mL (see Table 2) Hydroxyflubromazepam: 100 ng/mL Pregabalin: approx. 0.062 μg/mL		
		Serum (81 hours after hospital admission)	280 ng/mL	U-47700: 4.2 ng/mL (see Table 2) Hydroxyflubromazepam: 55 ng/mL Pregabalin: approx. 0.062 μg/mL		
Flubromazolam	male, 32 years old	Femoral blood	0.009 μg/g	Oxycodone: 0.10 μg/g Amphetamine: 0.13 μg/g MT-45: 0.11 μg/g (see Table 2) 3-methoxy-phencyclidine (3-MeO-PCP): 0.06 μg/g (see Table 3) 4-methoxy-phencyclidine (4-MeO-PCP): 0.03 μg/g (see Table 3) THJ-018: positive THC: 0.0011 μg/g	Mixed drug intoxication; accident	[101]
Flubromazolam	male, 29 years old	Femoral blood	0.01 μg/g	Nordazepam: 0.09 μg/g Pregabalin: 14 μg/g 3-methoxy-phencyclidine (3-MeO-PCP): 0.12 μg/g (see Table 3) AB-FUBINACA: positive (see Table 1) THJ-018: positive Buprenorphine: 2.0 ng/g Norbuprenorphine: 2.3 ng/g Methylphenidate: 0.020 μg/g Ritalinic acid: 0.48 μg/g	Asphyxia; suicide	[101]
Flubromazolam	male, 32 years old	Peripheral blood	3.5 ng/mL	Blood Ethanol: 0.37 g/L Cyclopropylfentanyl: 37.2 ng/mL (see Table 2) Codeine: 11 ng/mL Morphine: 310 ng/mL 6-monoacetylmorphine: 3.9 ng/mL Diphenhydramine: 350 ng/mL	Combined drug toxicity; accident	[76]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Flubromazolam	male, 43 years old	Peripheral blood	4.9 ng/mL	Blood: Cyclopropylfentanyl: 4.0 ng/mL (see Table 2) Codeine: 14 ng/mL Morphine: 230 ng/mL 6-monoacetylmorphine: 8.1 ng/mL 10-Hydroxycarbazepine: 15 ng/mL Quetiapine: 610 ng/mL Diphenhydramine: 97 ng/mL	Combined drug toxicity; accident	[76]
Heliomethylamine	male, 26 years old	Femoral blood	approx. 150 ng/mL	3,4-Dimethylcathinone (3,4-DMMC): approx. 500 ng/mL (see Table 3)	Acute poisoning by new psychoactive substances	[93]
		Urine	approx. 10000 ng/mL	3,4-Dimethylcathinone (3,4-DMMC): approx. 21700 ng/mL (see Table 3)		
		Gastric contents	approx. 14600 ng/mL	3,4-Dimethylcathinone (3,4-DMMC): approx. 5000 ng/mL (see Table 3)		
		Bile fluid	approx. 900 ng/mL	3,4-Dimethylcathinone (3,4-DMMC): approx. 10 ng/mL (see Table 3)		
		Heart blood	approx. 1600 ng/mL	3,4-Dimethylcathinone (3,4-DMMC): approx. 1500 ng/mL (see Table 3)		
		Liver	approx. 50 ng/mg	3,4-Dimethylcathinone (3,4-DMMC): approx. 20 ng/mg (see Table 3)		
MBDB (N-methyl-1-(3,4-methylenedioxyphenyl)-2-butanamine)	female, 19 years old	Blood	0.435 μg/mL	Amphetamine: 2.1 μg/mL BDB (1-(3,4-Methylenedioxyphenyl)-2-butanamine, MBDB metabolite): 0.106 μg/mL	Possibly cardiac arrhythmia	[135]
		Stomach contents	5.2 μg/mL	Amphetamine: 9 μg/mL BDB (1-(3,4-Methylenedioxyphenyl)-2-butanamine, MBDB metabolite): <1 μg/mL		
MBDB (N-methyl-1-(3,4-methylenedioxyphenyl)-2-butanamine)	male, 33 years old	Peripheral blood	1.2 μg/mL	Ethanol: 0.15 g/L	Trauma, fall from a height	[135]
MDAI (5,6-methylenedioxy-2-aminoindane)	male, 28 years old	Blood	2.09 μg/mL	EAPB (Ethylaminopropylbenzofuran): 6.45 μg/mL (see Table 3) Methylaminopropylbenzofuran (MAPB): 0.089 μg/mL Aminopropylbenzofuran (APB, EAPB metabolite): 0.546 μg/mL		[127] (abstract only)
		Urine	69.4 μg/mL	EAPB (Ethylaminopropylbenzofuran): 14.8 μg/mL (see Table 3) Methylaminopropylbenzofuran (MAPB): 1.0 μg/mL Aminopropylbenzofuran (APB, EAPB metabolite): 4.88 μg/mL Oxazepam		
MDPBP (3',4'-Methylenedioxy-α-pyrrolidinobutyrophenone)	N=1	Blood	1.55 μg/mL		Drugs death	[82]
MDPHP (3',4'-Methylenedioxy-α-pyrrolidinohexiophenone)	N=14 (13 males, 1 female, 24-54 years old)	Femoral blood	<0.05 μg/mL-1.14 μg/mL			[136] (abstract only)
MDPV (3,4-methylenedioxypyrovalerone)	male, 40 years old	Serum (antemortem)	82 ng/mL	Trimethoprim: 2.2 μg/mL Salicylate: 79 μg/mL Acetaminophen: 2.9 μg/mL Lithium: positive Initial drug screen (matrix unknown) positive for acetaminophen, caffeine, cotinine, lidocaine, trimethoprim and MDPV	Excited delirium syndrome followed by sudden pulseless electrical activity arrest, return of spontaneous circulation, subsequent development of coagulopathy, rhabdomyolysis, renal failure, hepatic failure, anoxic brain injury and death	[137]
		Urine (antemortem)	670 ng/mL	Trimethoprim: 12 μg/mL		
MDPV (3,4-methylenedioxypyrovalerone)	male, 37 years old	Heart blood	56 ng/mL	Methylone: 729 ng/mL (see Table 3) THC: 15 ng/mL THC-COOH: 118 ng/mL	Motor vehicle accident	[138]
		Bile	412 ng/mL	Methylone: >400 ng/mL (see Table 3)		
		Vitreous humor	33 ng/mL	Methylone: >200 ng/mL (see Table 3)		

MDPV (3,4-methylenedioxypyrovalerone)	male, 20 years old	Cavity blood	31 ng/mL	Urine: MDPV (3,4-methylenedioxypyrovalerone): positive	Motor vehicle accident	[138]
MDPV (3,4-methylenedioxypyrovalerone)	male, 39 years old	Femoral blood	91 ng/mL	Lidocaine: 100 ng/mL	MDPV intoxication; accident	[138]
		Vitreous humor	132 ng/mL			
		Urine	>200 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 29 years old	Heart blood	129 ng/mL	Historic THC use	Hanging, suicide	[138]
		Vitreous humor	20 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 34 years old	Femoral blood	185 ng/mL	Morphine: 24 ng/mL Fluoxetine: 760 ng/mL Norfluoxetine: 1600 ng/mL Trazodone: 70 ng/mL Mirtazapine: <50 ng/mL	Multiple drug intoxication; accident	[138]
		Vitreous humor	195 ng/mL			
		Urine	>200 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 46 years old	Heart blood	10 ng/mL		Natural	[138]
		Hospital blood	<5 ng/mL	Diphenhydramine: 230 ng/mL Alprazolam: 15 ng/mL Tramadol: <50 ng/mL Historic heroin use		
		Brain	16 ng/g			
		Liver	12 ng/g			
		Vitreous humor	17 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	female, 33 years old	Femoral blood	46 ng/mL	Morphine: 390 ng/mL Hydrocodone: 179 ng/mL Citalopram: 320 ng/mL Cocaine: <50 ng/mL Benzoylecgonine: >700 ng/mL Alprazolam: 50 ng/mL 6-monoacetylmorphine was not detected in blood, vitreous	Multiple drug intoxication; accident	[138]
		Vitreous humor	48 ng/mL			
		Urine	>200 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 47 years old	Peripheral blood	162 ng/mL	Oxymorphone: 43 ng/mL Diazepam: 313 ng/mL Nordiazepam: 494 ng/mL Temazepam: 33 ng/mL Diphenhydramine: 80 ng/mL	Multiple drug intoxication; accident	[138]
		Heart blood	280 ng/mL			
		Liver	3720 ng/g			
		Bile	>750 ng/mL			
		Urine	13900 ng/mL			
		Cerebrospinal fluid	105 ng/mL			
		Brain	168 ng/g			
		Vitreous	159 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 33 years old	Liver	>4800 ng/g	Ethanol: 0.44 g/L (matrix unknown) Trazodone: presumptively identified beta-phenethylamine: positive	MDPV intoxication; accident	[138]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
MDPV (3,4-methylenedioxypyrovalerone)	female, 43 years old	Peripheral blood	18 ng/mL	Fentanyl: 8 ng/mL Norfentanyl: <1 ng/mL Trazodone: 540 ng/mL Gabapentin: 6800 ng/mL Norvenlafaxine: 220 ng/mL Tramadol: <50 ng/mL Diazepam: 301 ng/mL Nordiazepam: 281 ng/mL	Multiple drug intoxication; accident	[138]
		Heart blood	28 ng/mL			
		Brain	<20 ng/g			
		Cerebrospinal fluid	14 ng/mL			
		Liver	52 ng/g			
		Vitreous humor	14 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 51 years old	Femoral blood	129 ng/mL	Bupropion (metabolite): 24 (216) ng/mL Morphine: 40 ng/mL Oxycodone: <20 ng/mL Diazepam: 303 ng/mL Nordiazepam: 229 ng/mL Ethylene glycol: not detected Modafinil/valproic Acid: not tested	Multiple drug intoxication; accident	[138]
		Liver	388 ng/g			
		Vitreous humor	191 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 32 years old	Peripheral blood	102 ng/mL	Chlorpheniramine: <50 ng/mL Dextromethorphan: 60 ng/mL	Hanging; suicide	[138]
		Heart blood	133 ng/mL			
		Brain	136 ng/g			
		Liver	256 ng/g			
		Cerebrospinal fluid	>200 ng/mL			
		Vitreous humor	205 ng/mL			
		Bile	>200 ng/mL			
		Urine	6100 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 32 years old	Peripheral blood	36 ng/mL	Citalopram: 200 ng/mL JWH-122: positive (see Table 1) JWH-210: positive (see Table 1) Trazodone: 50 ng/mL	Natural	[138]
		Heart blood	56 ng/mL			
		Brain	148 ng/g			
		Liver	668 ng/g			
		Bile	unsuitable for analysis			
		Vitreous humor	130 ng/mL			
		Cerebrospinal fluid	52 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	female, 53 years old	Cavity blood	positive	Benzoylecgonine: >1000 ng/mL Morphine: 212 ng/mL Alprazolam: 15 ng/mL Promethazine: 200 ng/mL Citalopram: 1100 ng/mL Diphenhydramine: 330 ng/mL Dextromethorphan: 140 ng/mL Trazodone: 140 ng/mL Cyclobenzaprine: 380 ng/mL	Multiple drug intoxication; accident	[138]
		Brain	20 ng/g			
		Liver	432 ng/g			
		Bile	140 ng/mL			
		Vitreous humor	48 ng/mL			
		Spleen	80 ng/g			
		Cerebrospinal fluid	33 ng/mL			

MDPV (3,4-methylenedioxypyrovalerone)	male, 19 years old	Femoral blood	63 ng/mL	Cyclobenzaprine: 60 ng/mL Dextromethorphan: <50 ng/mL Midazolam: <10 ng/mL Hydromorphone: <5 ng/mL Ethanol: 0.12 g/L	Natural	[138]
		Urine	>200 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 24 years old	Femoral blood	640 ng/mL	-	Hanging; suicide	
		Brain	896 ng/g			
		Liver	6080 ng/g			
		Bile	1880 ng/mL			
		Vitreous humor	940 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	female, 32 years old	Femoral blood	47 ng/mL	Femoral blood: Nordiazepam: 12 ng/mL Free morphine: 37 ng/mL Dextromethorphan: not detected Vitreous: 6-monoacetylmorphine: 7 ng/mL Urine: MDPV (3,4-methylenedioxypyrovalerone): positive (see Table 3) α-PVP: positive (see Table 3) Methedrone: positive (see Table 3)	Multiple drug intoxication; accident	[138]
MDPV (3,4-methylenedioxypyrovalerone)	male, 39 years old	Heart blood	0.7 μg/mL	Diphenhydramine: 0.1 μg/mL Promethazine: 0.2 μg/mL Nordiazepam: 0.1 μg/mL	MDPV intoxication; accident	[139]
		Peripheral blood	1.0 μg/mL			
MDPV (3,4-methylenedioxypyrovalerone)	female, 21 years old	Heart blood	0.47 μg/mL	Morphine: 0.031 μg/mL Methylone: 0.06 μg/mL (see Table 3)	Drowning (multiple blunt force injuries); accident	[140]
		Liver	0.53 μg/g	Methylone: 0.14 μg/g (see Table 3)		
		Kidney	0.49 μg/g	Methylone: 0.16 μg/g (see Table 3)		
		Bile	0.58 μg/mL	Methylone: 0.42 μg/mL (see Table 3)		
MDPV (3,4-methylenedioxypyrovalerone)	female, 35 years old	Heart blood	0.03 μg/mL	Methylone: 1.12 μg/mL (see Table 3)	Cutting wound of neck and gunshot wound of head; homicide	[140]
		Urine	not detected	Methylone: 0.22 μg/mL (see Table 3)		
		Liver	not detected	Methylone: 1.3 μg/g (see Table 3)		
		Kidney	not detected	Methylone: 0.91 μg/g (see Table 3)		
MDPV (3,4-methylenedioxypyrovalerone)	male, 28 years old	Peripheral blood	70 ng/mL	Bromazepam: 0.05 ng/mL Cocaine: <5 ng/mL Benzoylecgonine: 20 ng/mL Methylecgonine: 6 ng/mL Morphine: 3 ng/mL Codeine: 2.1 ng/mL		[105]
MDPV (3,4-methylenedioxypyrovalerone)	female, 35 years old	Cardiac blood	1200 ng/mL	α-pyrrolidinobutiophenone (α-PBP): 200 ng/mL (see Table 3) Hair samples positive for MDPV, α-pyrrolidinovalerophenone (α-PVP) and α-pyrrolidinobutiophenone (α-PBP)	Acute MDPV poisoning	[141]
MDPV (3,4-methylenedioxypyrovalerone)	male, 47 years old	Blood	1.09 μg/mL	Caffeine: positive Lidocaine: positive	Probable MDPV contribution to death by causing fatal cardiac arrhythmia	[142] (abstract only)
		Urine	60.3 μg/mL			
MDPV (3,4-methylenedioxypyrovalerone)	N=3	Blood	<0.1 μg/mL 0.41 μg/mL 1.55 μg/mL		Drugs death	[82]
MDPV (3,4-methylenedioxypyrovalerone)	N=5	Blood	0.06 μg/mL <0.3125 μg/mL 0.11 μg/mL 0.38 μg/mL 0.62 μg/mL		Alternative, not drug related, cause of death	[82]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
MDPV (3,4-methylenedioxypyrovalerone)	male, 46 years old	Femoral blood	39 ng/mL	Femoral blood: Metoclopramide: 490 ng/mL Vitreous humor: Acetone: 106 mg/dL Glucose: >1200 mg/dL Urea nitrogen: 51 mg/dL Creatinine: 2.9 mg/dL Serum tryptase: 17 μg/L	Diabetic ketoacidosis in a setting of MDPV abuse	[143]
		Urine	760 ng/mL	Metoclopramide: positive		
MDPV (3,4-methylenedioxypyrovalerone)	male, 40 years old	Femoral blood	130 ng/mL	Caffeine: positive Butalbital: 5.1 μg/mL Dextromethorphan/levomethorphan: 250 ng/mL.	Complications of HIV in a setting of MDPV abuse	[143]
		Urine	3800 ng/mL	Drug screen positive for caffeine, barbiturates, bupropion, dextromethorphan and metabolites, diphenhydramine and metabolites and phenothiazines		
MDPV (3,4-methylenedioxypyrovalerone)		Blood	170 ng/mL			[144]
		Urine	1400 ng/mL			
MDPV (3,4-methylenedioxypyrovalerone)	male, 39 years old	Femoral blood	440 ng/mL	Blood: Lamotrigine: <0.4 μg/mL Fluoxetine: 290 ng/mL Risperidone: 6.8 ng/mL Hydroxyrisperidone: 6.3 ng/mL Pseudoephedrine: 130 ng/mL Benztropine: 10 ng/mL Caffeine: positive Ibuprofen: positive Nicotine/Cotinine: positive	MDPV intoxication resulting in cardiac arrhythmia	[145]
		Heart blood	500 ng/mL			
		Urine	>5000 ng/mL	Nicotine: positive Cotinine: positive Pseudoephedrine: positive m-chlorophenylpiperazine: positive Methylone: positive (see Table 3)		
		Gastric	>2000 ng/mL			
		Bile	880 ng/mL			
		Cerebrospinal fluid	410 ng/mL			
		Lung	600 ng/mg			
		Kidney	840 ng/mg			
		Liver	980 ng/mg			
		Muscle	560 ng/mg			
		Spleen	640 ng/mg			
		Brain: Parietal	360 ng/mg			
		Brain: Cerebellum	420 ng/mg			
		Brain: Lentiform nucleus	300 ng/mg			
		Brain: Frontal	300 ng/mg			
		Brain: Occipital	420 ng/mg			
		Brain: Medulla	420 ng/mg			
		Heart	120 ng/mg			
		Hair	11660 pg/mg	Methylone: 1332 pg/mg (see Table 3)		

Mephedrone (4-methylmethcathinone, 4-MMC)	male, 36 years old	Femoral blood	5.1 μg/mL	Femoral blood: Cocaine: 0.0071 μg/mL Benzoylecgonine: 0.17 μg/mL Methylecgonine: 0.042 μg/mL MDMA: 0.011 μg/mL Oxazepam: <0.010 μg/mL Midazolam (given by medical personnel): 0.0064 μg/mL Blood from the heart: Metanephrine (metabolite of epinephrine): traces may be present Atropine: traces may be present (epinephrine and atropine were administered during resuscitation)	Fatal oral intake of mephedrone, aggravated by blood loss from multiple wounds	[146]
		Urine	186 μg/mL			
		Stomach contents	113 mg / 94 mg 1.04 mg/mL	–		
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 39 years old	Femoral blood	22 ng/mL	Blood: U-47700: 217 ng/mL (see Table 2) Etizolam: positive (see Table 3)		[66]
Mephedrone (4-methylmethcathinone, 4-MMC)	N = 37	Blood	Mean: 1.938 μg/mL Range: <0.01-22.0 μg/mL			[147]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 22 years old	Blood	0.50 μg/mL	Morphine: 0.06 μg/mL	Multiple-drug toxicity associated with mephedrone and heroin use; accident	[148]
		Urine	198 μg/mL	6-acetylmorphine: 0.53 μg/mL Morphine: 27.13 μg/mL Codeine: 1.86 μg/mL Doxylamine: 1.99 μg/mL		
Mephedrone (4-methylmethcathinone, 4-MMC)		Peripheral blood	0.11 ng/mL	4-Methylethcathinon (4-MEC): 0.25 ng/mL (see Table 3) Pentedrone: 0.22 ng/mL (see Table 3) Paracetamol: 5.4 ng/mL Pheniramine: 0.43 ng/mL Bromazepam: 0.04 ng/mL Benzoylecgonine: 150 ng/mL Methylecgonine: 54 ng/mL GHB: 519 μg/mL		[105]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 39 years old	Peripheral blood	604 ng/mL	Amphetamine: 938 ng/mL		[105]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 28 years old	Peripheral blood	5432 ng/mL	Cocaine: 43 ng/mL Benzoylecgonine: 1690 ng/mL Norcocaine: 6 ng/mL		[105]
Mephedrone (4-methylmethcathinone, 4-MMC)	female, 49 years old	Femoral venous blood	0.98 μg/mL	Femoral venous blood: Atropine: positive Naloxone: positive (both from resuscitation attempts) Urine and stomach contents: Mephedrone: positive Paracetamol: positive	Adverse effects of mephedrone with atherosclerotic coronary artery disease and myocardial fibrosis being contributing factors	[149]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 19 years old	Femoral venous blood	2.24 μg/mL	Femoral venous blood: Atropine: positive 3-trifluoromethylphenylpiperazine (3-TFMPP): positive Urine: Mephedrone: positive Acetone: positive Ethanol: 0.15 g/L	Cardio-respiratory arrest; mephedrone was considered to be the principal cause of death	[149]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Mephedrone (4-methylmethcathinone, 4-MMC)	female, 55 years old	Femoral venous blood	0.13 μg/mL	Femoral venous blood: Diazepam: positive Nordiazepam: positive Olanzapine: positive Chlorpromazine metabolites Methadone: 0.3 μg/mL Urine: Methadone: positive EDDP: positive Procyclidine: positive	Multiple drug toxicity death (methadone and mephedrone)	[149]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 17 years old	Femoral venous blood	0.24 μg/mL	Stomach contents and urine: Mephedrone: positive	Multiple blunt force injuries (mephedrone may have affected the ability to drive, leading to a fatal vehicular collision)	[149]
Mephedrone (4-methylmethcathinone, 4-MMC)	N=12	Blood	0.15 μg/mL 0.21 μg/mL 0.36 μg/mL 0.50 μg/mL 0.68 μg/mL 1.20 μg/mL (antemortem) 1.30 μg/mL 1.31 μg/mL 1.51 μg/mL 2.09 μg/mL 2.17 μg/mL 3.06 μg/mL		Drugs death	[82]
Mephedrone (4-methylmethcathinone, 4-MMC)	N=24	Blood	0.02-2.23 μg/mL		Alternative, not drug related, cause of death	[82]
Mephedrone (4-methylmethcathinone, 4-MMC)		Blood	22 μg/mL	Diazepam: <0.1 μg/mL Nordiazepam: <0.1 μg/mL Amphetamine: 0.34 μg/mL	Mephedrone intoxication	[150]
		Urine	Positive			
Mephedrone (4-methylmethcathinone, 4-MMC)		Blood	3.3 μg/mL		Mephedrone intoxication	[150]
		Urine	>0.50 μg/mL	Benzoylecgonine: positive THC-COOH: positive		
		Hair	4.2 and 4.7 ng/mg			
Mephedrone (4-methylmethcathinone, 4-MMC)		Blood	5.7 μg/mL			[150]
		Urine	positive			
Mephedrone (4-methylmethcathinone, 4-MMC)		Blood	1.2 μg/mL		Stab wound of the abdomen	[150]
Mephedrone (4-methylmethcathinone, 4-MMC)	male, 29 years old	Femoral blood	1300 ng/mL	Ephedrone (methcathinone): 210 ng/mL (see Table 3) Ethanol: 2.80 ‰	Acute circulatory and respiratory failure resulting from complex intoxication with cathinone derivatives, including mephedrone and methcathinone (in an alcohol-addicted man who was under the influence)	[122]
Mephedrone (4-methylmethcathinone, 4-MMC)	N=45	Blood	0.01-95.8 μg/mL			[126]
	N=27	Urine	0.47-998 μg/mL			
	N=8	Gastric contents	0.03-471 μg/mL			

Methedrone (4-Methoxymethcathinone)	male, 23 years old	Antemortem blood	13.2 μg/g		Accidental poisoning	[151]
		Femoral blood	8.4 μg/g	Diazepam: 0.05 μg/g Midazolam: 0.02 μg/g Lidocaine: 0.6 μg/g All substances were administered at the hospital.		
Methedrone (4-Methoxymethcathinone)	male, 19 years old	Femoral blood	9.6 μg/g	Urine: Acetone: 0.37 g/L	Accidental poisoning	[151]
		Hair	positive in five short segments (29-37 ng/mg)			
Methiopropamine (MPA)	male, 39 years old	Peripheral blood	1041 ng/mL	5-(2-aminopropyl) benzofuran (5 APB): 4970 ng/mL (see Table 3) Methylphenidate: 44 ng/mL MDPV metabolite: positive Aripiprazole: 80 ng/mL Mirtazapine: 80 ng/mL Tropatepine: 130 ng/mL Oxazepam: 120 ng/mL		[105]
Methiopropamine (MPA)	N=5	Blood	0.06 μg/mL 0.43 μg/mL 1.4 μg/mL 2.8 μg/mL 6.7 μg/mL		Drugs death	[82]
Methiopropamine (MPA)	N=1	Blood	0.31 μg/mL		Alternative, not drug related, cause of death	[82]
Methiopropamine (MPA)		Femoral blood	1.3 μg/g	MT-45: 0.46 μg/g (see Table 2) Gabapentin: 27 μg/g Flubromazepam: 0.43 μg/g (see Table 3) Pyrazolam: positive Ethylphenidate: positive (see Table 3)	Mixed intoxication	[99]
Methoxetamine	male, 39 years old	Peripheral blood	>3 μg/mL	HbCO: 77 %		[105]
Methoxetamine	N=3	Blood	0.89 μg/mL 2.04 μg/mL 2.15 μg/mL		Drugs death	[82]
Methoxetamine	N=2	Blood	0.55 μg/mL 1.21 μg/mL		Alternative, not drug related, cause of death	[82]
Methoxetamine	female	Peripheral blood	64 ng/mL	AH-7921: 0.33 μg/mL (see Table 2) Etizolam: 0.27 μg/mL (see Table 3) Phenazepam: 1.33 μg/mL 7-aminonitrazepam: 0.043 μg/mL Diazepam: 0.046 μg/mL Nordiazepam: 0.073 μg/mL Oxazepam: 0.018 μg/mL	Intoxication with AH-7921 in combination with several benzodiazepines and methoxetamine	[84]
Methoxphenidine	male, 54 years old	Peripheral blood	7477 ng/mL	3-Fluorophenmetrazine: 302 ng/mL (see Table 3) Laudanosine: 1.15 μg/mL Citalopram: 200 ng/mL Midazolam: 60 ng/mL Lidocaine: <1 μg/mL Darunavir : 4.3 μg/mL Fosamprenavir: 30 ng/mL Ritonavir: 60 ng/mL Benzoylecgonine: 119 ng/mL Methylecgonine: 9 ng/mL		[105]
Methylone	male, 16 years old	Blood	272 ng/mL		Sudden cardiac death (steatosis of the heart muscle, congenital heart disease and bronchial asthma presumed as predisposing factors)	[152] (abstract only)
		Liver	387 ng/g			
Methylone	male, 19 years old	Central blood	0.7 μg/mL	–	Sudden cardiac death associated with methylone use	[153]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
Methylone	male, 21 years old	Peripheral blood	3.13 μg/mL	THC: 12.9 ng/mL 11-OH-THC: 4.9 ng/mL THC-COOH: 29.3 ng/mL	Respiratory distress probably provoked by the absorption of toxic substances	[154]
		Central blood	6.64 μg/mL			
		Urine	502 μg/mL			
		Bile	35.3 μg/mL			
		Gastric contents	57.3 μg/mL			
		Vitreous humor	5.04 μg/mL			
Methylone	male, 19 years old	Central blood	0.74 μg/mL		Cardiac arrest associated with methylone; accident	[140]
		Peripheral blood	0.67 μg/mL			
		Urine	38 μg/mL			
		Liver	1.8 μg/g			
		Kidney	2.3 μg/g			
		Spleen	2.1 μg/g			
		Bile	1.8 μg/mL			
Methylone	male, 38 years old	Heart blood	0.118 μg/mL	Hydrocodone: 0.1 μg/mL Acetaminophen: 23 μg/mL	Contact gunshot wound to head; suicide	[140]
		Urine	0.25 μg/mL			
		Liver	0.55 μg/g			
		Kidney	0.26 μg/g			
		Bile	0.52 μg/mL			
Methylone	female, 21 years old	Heart blood	0.06 μg/mL	Morphine: 0.031 μg/mL Methylenedioxypyrovalerone (MDPV): 0.47 μg/mL (see Table 3)	Drowning (multiple blunt force injuries); accident	[140]
		Liver	0.14 μg/g	Methylenedioxypyrovalerone (MDPV): 0.53 μg/g (see Table 3)		
		Kidney	0.16 μg/g	Methylenedioxypyrovalerone (MDPV): 0.49 μg/g (see Table 3)		
		Bile	0.42 μg/mL	Methylenedioxypyrovalerone (MDPV): 0.58 μg/mL (see Table 3)		
Methylone	female, 35 years old	Heart blood	1.12 μg/mL	Heart blood: Methylenedioxypyrovalerone (MDPV): 0.03 μg/mL (see Table 3)	Cutting wound of neck and gunshot wound of head; homicide	[140]
		Urine	0.22 μg/mL	MDPV not detected in urine, liver or kidney		
		Liver	1.3 μg/g			
		Kidney	0.91 μg/g			
Methylone	male, 37 years old	Heart blood	729 ng/mL	MDPV (3,4-methylenedioxypyrovalerone): 56 ng/mL (see Table 3) THC: 15 ng/mL THC-COOH: 118 ng/mL	Motor vehicle accident	[138]
		Bile	>400 ng/mL	MDPV (3,4-methylenedioxypyrovalerone): 412 ng/mL (see Table 3)		
		Vitreous humor	>200 ng/mL	MDPV (3,4-methylenedioxypyrovalerone): 33 ng/mL (see Table 3)		
Methylone	male, 21 years old	Peripheral blood	3130 ng/mL	THC: 19.2 ng/mL 11-OH-THC: 29.3 ng/mL THC-COOH: 4.9 ng/mL		[105]
Methylone	female, 19 years old	Peripheral blood (left common iliac vein)	3.4 μg/mL	THC: 3.2 ng/mL THC-COOH: 110 ng/mL	Drowning due to acute methylone intoxication; accident	[155]
		Central blood (intrapericardial inferior vena cava)	3.4 μg/mL			
		Vitreous humor	4.3 μg/mL			
		Liver	11 μg/g			
		Gastric contents	1.7 mg			
Methylone	male, 23 years old	Peripheral blood (iliac blood)	0.84 μg/mL	Dextromethorphan: <0.02 μg/mL Cotinine: positive Caffeine: positive Lidocaine: positive	Methylone intoxication; accident	[156]
		Antemortem blood	0.70, 0.66, 0.60, 0.61 and 0.62 μg/mL at 0, 3, 7, 23 and 25 h after admission			
		Heart blood	1.0 μg/mL			
		Vitreous humor	1.4 μg/mL			
		Urine	0.55 μg/mL			
		Gastric contents	12 μg/mL			

Methylone	female, 19 years old	Peripheral blood	3.3 μg/mL	Femoral blood: Lamotrigine: 2.5 μg/mL	Acute methylone intoxication; accident	[156]
Methylone	male, 23 years old	Peripheral blood	0.56 μg/mL	Peripheral blood: Ethanol: 0.3 g/L Blood: Midazolam: 0.020 μg/mL Lorazepam: 0.029 μg/mL Fentanyl: 0.0021 μg/mL (all administered by the hospital)	Methylone intoxication	[156]
		Heart blood	0.58 μg/mL			
		Liver	0.88 μg/g			
		Vitreous humor	0.92 μg/mL	Ethanol: 0.1 g/L		
		Urine	230 μg/mL			
		Gastric contents	4.5 μg/mL			
Methylone	N=3	Blood	0.10 μg/mL 4.31 μg/mL 11.0 μg/mL		Drugs death	[82]
Methylone	female, 24 years old	Urine	positive	Butylone (see Table 3)	Serotonin syndrome secondary to methylone and butylone	[125]
Methylone	N=50	Blood	0.01-142 μg/mL			[126]
	N=31	Urine	0.02-106 μg/mL			[126]
	N=13	Gastric contents	0.01-9112 μg/mL			[126]
α-Methyltryptamine (AMT)	N=9	Blood	0.48 μg/mL 0.29 μg/mL 0.89 μg/mL 1.00 μg/mL 0.75 μg/mL (antemortem) 0.32 μg/mL 0.16 μg/mL 0.19 μg/mL 1.3 μg/mL		Drugs death	[82]
para-methoxyamphetamine (PMA)	N=16	Blood	<0.625 μg/mL 0.72 μg/mL 0.86 μg/mL 0.92 μg/mL (antemortem) 1.09 μg/mL 1.39 μg/mL 1.44 μg/mL 1.47 μg/mL 1.50 μg/mL 1.59 μg/mL (antemortem) 1.61 μg/mL (antemortem) 2.35 μg/mL 2.62 μg/mL 3.18 μg/mL 4.3 μg/mL 29.2 μg/mL		Drugs death	[82]
para-methoxyamphetamine (PMA)	N=1	Blood	<0.625 μg/mL		Alternative, not drug related, cause of death	[82]

Table 3 (*Continued*)

Substance	Deceased	Body fluid/tissue	Substance concentration	Further detected substances	Cause of death	Reference
para-methoxyamphetamine (PMA)	male	Blood	2347 ng/mL	4-methylethcathinone (4-MEC): 56 ng/mL (see Table 3) para-methoxymethylamphetamine (PMMA): 30 ng/mL (see Table 3) Amphetamine: 378 ng/mL Methamphetamine: 48 ng/mL THC: 1.3 ng/mL THC-COOH: 8.7 ng/mL	Overdose of para-methoxyamphetamine (PMA), multiple-drug toxicity	[121]
		Urine	50.1 μg/mL	4-methylethcathinone (4-MEC): 14.3 μg/mL (see Table 3) para-methoxymethylamphetamine (PMMA): 1.7 μg/mL (see Table 3) Amphetamine: positive THC-COOH: 54.7 ng/mL		
		Stomach contents	positive	4-methylethcathinone (4-MEC): positive (see Table 3) para-methoxymethylamphetamine (PMMA): positive (see Table 3)		
para-methoxymethylamphetamine (PMMA)	N=5	Blood	1.64 μg/mL 2.17 μg/mL 2.18 μg/mL 2.9 μg/mL 3.3 μg/mL		Drugs death	[82]
para-methoxymethylamphetamine (PMMA)	male	Blood	30 ng/mL	4-methylethcathinone (4-MEC): 56 ng/mL (see Table 3) para-methoxyamphetamine (PMA): 2347 ng/mL (see Table 3) Amphetamine: 378 ng/mL Methamphetamine: 48 ng/mL THC: 1.3 ng/mL THC-COOH: 8.7 ng/mL	Overdose of para-methoxyamphetamine (PMA), multiple-drug toxicity	[121]
		Urine	1.7 μg/mL	4-methylethcathinone (4-MEC): 14.3 μg/mL (see Table 3) para-methoxyamphetamine (PMA): 50.1 μg/mL (see Table 3) Amphetamine: positive THC-COOH: 54.7 ng/mL		
		Stomach contents	positive	4-methylethcathinone (4-MEC): positive (see Table 3) para-methoxyamphetamine (PMA): positive (see Table 3)		
Pentedrone		Peripheral blood	0.22 ng/mL	4-methylethcathinone (4-MEC): 0.25 ng/mL (see Table 3) Mephedrone (4-MMC): 0.11 ng/mL (see Table 3) Paracetamol: 5.4 ng/mL Pheniramine: 0.43 ng/mL Bromazepam: 0.04 ng/mL Benzoylecgonine: 150 ng/mL Methylecgonine: 54 ng/mL GHB: 519 ng/mL		[105]
Pentylone	N=1	Blood	0.34 μg/mL		Drugs death	[82]
Pentylone	N=1	Blood	0.012 μg/mL			[126]
	N=1	Gastric contents	0.024 μg/mL			
PV9	female, 18 years old	Antemortem whole blood	45.7 ng/mL	Caffeine: positive	Drug poisoning with PV9	[157,158]
		Antemortem urine	20.3 ng/mL			
		Femoral blood	180 ng/mL			
		Brain	212 ng/g			
		Lung	337 ng/g			
		Heart muscle	258 ng/g			
		Liver	377 ng/g			
		Spleen	269 ng/g			
		Kidney	907 ng/g			
		Pancreas	628 ng/g			
		Skeletal muscle	686 ng/g			
		Adipose tissue	526 ng/g			
PV9	female	Femoral blood	0.743 μg/mL	Diphenidine: 1.38 μg/mL(see Table 3) 4-methoxy PV8: 2.69 μg/mL(see Table 3) 4-methoxy PV9: 0.261 μg/mL(see Table 3) Ethanol: 1.52 g/L Presence of triazolam, flunitrazepam, nitrazepam and their metabolites	4-methoxy PV8, PV9, 4-methoxy PV9 and diphenidine poisoning under the influence of three benzodiazepines and alcohol	[118] (abstract only)

Pyrovalerone	male, 33 years old	Femoral blood	42 ng/mL	Femoral blood: Pentylone: positive (see Table 3) Amphetamine: <50 ng/mL Urine also contained MDPV All specimens positive for pentylone	Autoerotic asphyxia; accident	[138]
		Heart blood	59 ng/mL			
		Brain	48 ng/g			
		Liver	124 ng/g			
		Bile	70 ng/mL			
		Vitreous humor	24 ng/mL			
α-pyrrolidinobutiophenone (α-PBP)	female, 35 years old	Cardiac blood	200 ng/mL	MDPV (3,4-methylenedioxypyrovalerone): 1200 ng/mL (see Table 3) Hair samples positive for MDPV, α-pyrrolidinovalerophenone (α-PVP) and α-pyrrolidinobutiophenone (α-PBP)	Acute MDPV poisoning	[141]
α-pyrrolidinobutiophenone (α-PBP)	male, 21 years old	Right heart blood	51.7 ng/mL	Blood: Caffeine: 349 ng/mL Acetaminophen: 752 ng/mL Allylisopropylacetylurea: 127 ng/mL	Subarachnoid hemorrhage	[159]
		Left heart blood	68.3 ng/mL			
		Femoral vein blood	55.2 ng/mL			
		Cerebrospinal fluid	41.4 ng/mL			
		Urine	906 ng/mL	Tyramine: 880 ng/mL Acetaminophen: 4.68 μg/mL		
		Stomach contents	725 ng/mL			
		Lung	125 ng/g			
		Liver	82.6 ng/g			
		Kidney	140 ng/g			
		Pancreas	106 ng/g			
		Spleen	121 ng/g			
α-PVP (2-pyrrolidino valerophenone, α-pyrrolidino valerophenone)	male, 32 years old	Peripheral blood	1500 ng/mL	THC: 3.3 ng/mL 11-OH-THC: 2 ng/mL THC-COOH: 14.2 ng/mL Alcohol: 3.65 g/L	Sudden cardiac death due to atherosclerotic heart disease combined with toxic pulmonary edema; possible involvement of alcohol and marijuana in precipitation of coronary vasospasm; accidental overdose	[160]
		Urine	>5000 ng/mL	Positive for cannabis by immunoenzymology tests Alcohol: positive		
α-PVP (2-pyrrolidino valerophenone, α-pyrrolidino valerophenone)	male, 41 years old	Right heart blood	458 ng/mL	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 298 ng/mL Whole blood: Caffeine: about 100 ng/mL	α-PVP poisoning	[161]
		Left heart blood	442 ng/mL	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 311 ng/mL		
		Femoral vein blood	654 ng/mL	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 364 ng/mL		
		Urine	11200 ng/mL	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 5300 ng/mL		
		Stomach contents	1030 ng/mL	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 175 ng/mL		
		Brain	518 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 592 ng/g		
		Lung	1070 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 576 ng/g		
		Heart muscle	1360 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 724 ng/g		
		Liver	681 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 1080 ng/g		
		Kidney	1580 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 972 ng/g		
		Pancreas	1780 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 537 ng/g		
		Spleen	318 ng/g	1-phenyl-2-(pyrrolidin-1-yl)pentan-1-ol (OH-α-PVP): 470 ng/g		
α-PVP (2-pyrrolidino valerophenone, α-pyrrolidino valerophenone)	male	Serum	411 ng/mL	–	Sudden cardiac death after sustained restraint	[162]
α-PVP (2-pyrrolidino valerophenone, α-pyrrolidino valerophenone)		Heart blood	486 ng/mL	–		[163]

*In certain countries etizolam is approved and prescribed for medical purposes.

that might influence the determined postmortem blood concentration is even more difficult as it is for commonly used drugs.

As a consequence of described postmortem drug concentration changes but also due to possible differences between postmortem whole blood and plasma or serum concentrations of living persons, the use of plasma / serum concentrations of NPS in living subjects for the interpretation of postmortem blood concentrations is of limited value. This fact is well investigated for a number of common drugs. Launiainen and Ojanperä compared postmortem femoral venous blood concentrations of more than 50,000 autopsy cases with described therapeutic plasma ranges. Only median postmortem femoral blood concentration of 61 out of 129 drugs was within the plasma reference range. For all other drugs median and thus postmortem concentrations assumed as "normal" were under or above therapeutic plasma range. Deviations were explained by several reasons including postmortem redistribution or common pattern of use of a certain drug [17]. A study of Linnet supports these discrepancies between serum reference ranges and postmortem blood drug concentration intervals [33].

In case of NPS, however, there are general difficulties establishing a representative plasma / serum or postmortem blood concentration range. The establishment of plasma / serum concentration ranges would require controlled dosing studies which is impossible for ethical reasons. Regarding postmortem concentrations, a number of death cases involving NPS are published as case reports or series. These are few cases usually accompanied by interesting or conspicuous observations. In contrast to common or therapeutic drugs (data compilations like [17,34,35]), the number of cases with NPS verification is scarce. Moreover, possibly low postmortem concentrations and analytical methods of not sufficient intensity as well as cases where involvement of NPS is not expected and thus specific methods are not conducted, might cause a number of cases remained unreported. Also this reflection should be considered while using published concentrations (of single case reports) for interpretation of postmortem drug levels. Not least, quality of methods used for the determination of the herein compiled postmortem concentration data and thus concentration accuracies might vary largely.

Furthermore, the knowledge of toxicokinetic and toxicodynamic parameters of substances (e.g. bioavailability, volume of distribution or half-life) may be necessary for comprehensive interpretation. For example, these values are useful checking the plausibility of an ingested drug amount. As such drug characteristics are generally assessed in healthy living people, an indubitable application to death cases is vague [16]. For new appearing psychoactive substances there might be no data regarding their pharmacokinetic and pharmacodynamic properties. Even for known NPS, effect mechanisms are not always completely understood impeding interpretation.

Regarding the deceased, information on age, general health or disease history, drug-taking history (e.g. estimating tolerance development) is useful with regard to drug level interpretation [16]. In cases where repeated ingestion of a NPS is assumed that might have led to tolerance development, hair analysis could provide additional information on drug taking history [20]. As for other postmortem matrices, hair testing in death cases is also subject to further influences. For example, an agony phase accompanied by intensive sweating (e.g. caused by hyperthermia) could facilitate incorporation of (new psychoactive) substances in scalp hair. Therefore, findings of substances in all hair sections during segmental analysis have not necessarily to be associated with a continuous exposure [36,37].

There are further considerations possibly complicating the interpretation of postmortem concentration of drugs including NPS. The route and speed of exposure should be taken into consideration evaluating toxicological findings. A rapid uptake, for example intravenously, of a NPS could establish a more toxic effect than caused by the same amount consumed otherwise [20]. Metabolic pathways of NPS as well as pharmacogenetic characteristics of users could also be of importance [20]. Interactions by other xenobiotics, genetic polymorphism (heavy or poor metabolizer) or liver disease might inhibit or intensify metabolic reactions of NPS. Depending on pharmacological or even toxic potency of NPS or their metabolites, effects can be elevated or weakened. However, as metabolism of new appearing substances has initially to be examined, potencies of metabolites are often not (yet) determined and metabolites are not always tested analytically, the sole consideration of the NPS itself can be misleading.

Elliott et al. proposed an approach estimating the toxicological significance of NPS in death investigations. The estimation is based on occurrence, concentration and nature of NPS, occurrence, concentration and nature of other drugs, circumstances of death, cited cause of death (including pathological findings) and, depending on the number of cases, a possible determination of typical concentrations in varying circumstances. The toxicological significance score is divided in low (alternative cause of death), medium (possible contribution of NPS to toxicity/death; other drugs present are more significant), high (likely contribution of NPS to toxicity/death) and unclassified (insufficient data available) [19]. Again, this classification emphasizes that, depending on the available information, a final assessment is not always possible ("unclassified") and that an evaluation of NPS contribution to the cause of death cannot be solely based on the blood levels of NPS.

The herein presented summary might be useful for the interpretation or plausibility control in upcoming death cases involving certain NPS and is intended to provide an overview of comparable cases published previously. For more details (e.g. corresponding case histories), it is always advisable to use the herein cited primary literature. Moreover, as presented within the discussion, interpreting postmortem concentrations is of high complexity. A comprehensive interpretation necessitates consideration of pharmacological properties of the drugs or NPS involved and consideration of the circumstances of death. Particularly because of possible postmortem drug concentration changes and individual characteristics of every particular case, determining the cause of death should never be based on a measured drug concentration solely. As a consequence, the herein presented concentrations should always be used with caution.

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