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17

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MODERN APPROACHES TO THE STUDY OF THE CHEMICAL-TOXICOLOGICAL CHARACTERISTICS OF PHENYLALKYLAMINES USING THE CASE STUDY METHOD

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ABSTRACT

The purpose of the investigation is to introduce the Case Study model into the pedagogical process when studying toxic substances. Among the highly toxic substances studied in the discipline "Toxicological and Forensic Chemistry", the group of phenylalkylamines attracts special attention. Phenamine or amphetamine, which is close to adrenaline and noradrenaline in chemical structure, is considered a classic psychomotor stimulant. Due to side effects in the form of disorders of the functions of the higher nervous system, frequent paradoxical reactions, the development of addiction and drug dependence, phenamine is not used in Ukraine. When teaching the discipline "Toxicological and Forensic Chemistry", phenylalkylamines are studied according to the following plan: representatives of the group and the peculiarity of their chemical structure, toxicological significance and symptoms of poisoning, objects of study, metabolic pathways and metabolites (active, inactive), isolation methods from research objects, methods of qualitative detection and quantitative determination of phenylalkylamines, antidote therapy. In order to ensure a comprehensive consideration of phenylalkylamines as objects of chemical and toxicological research in the educational process, it is important to use the Case study method. With the help of a case study, solutions are planned when studying the problems of chemical and toxicological analysis of phenylalkylamines and recommendations are developed for planning research - descriptive and problem cases, and the key strengths of the research are identified using a SWOT analysis. The current task remains to improve the educational material on the chemical and toxicological analysis of phenylalkylamines by highlighting the latest analysis methods and modern chemical modifications of the structure of compounds of this group. Using the example of a class of toxic substances - phenylalkylamines, the methods of implementing the Case Study model into the educational process were demonstrated, which confirmed its effectiveness and efficiency in mastering the discipline "Toxicological and Forensic Chemistry".

Keywords

Phenylalkylamines, amphetamine, chemical-toxicological analysis, toxicological and forensic chemistry, higher education, case study.

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INTRODUCTION

The discipline «Toxicological and Forensic Chemistry» is taught at the Faculty of Pharmacy of the O.O. Bogomolets National Medical University for 4th-year students in accordance with the educational program (EP) «Pharmacy» of the second (master's) level of higher education in the specialty I8 «Pharmacy» and opens up to students the opportunity to get acquainted with advanced methods of isolating and analyzing xenobiotics - poisonous and highly toxic substances in objects of various origins (cadaveric material, human biological fluids, plants, medicines, pesticides, etc.). A feature of chemical-toxicological analysis is the ability to detect and quantify xenobiotics and their metabolites, which often play an important role in the «lethal» synthesis in the body of a poisoned person. Among the class of poisonous «medicinal» substances, the group of phenylalkylamines attracts special attention. The derivative of phenylalkylamine - amphetamine or phenamine - has serious side effects in the form of disorders of the functions of the higher nervous system, causes paradoxical reactions and the development of addiction and drug dependence. Phenamine is not used in Ukraine. However, other phenylalkylamines are used in medical practice, which often cause suicidal and criminal poisoning of people. After taking 1 mg/kg of amphetamine, a person may die. The toxic dose of amphetamine depends on the individual sensitivity of the body and other factors. When teaching the discipline "Toxicological and Forensic Chemistry", phenylalkylamines are studied according to a comprehensive plan according to the Case study method. This method is used in the educational process to ensure a comprehensive consideration of phenylalkylamines as objects of chemical and toxicological research. With the help of Case studies, ways to solve problems of chemical and toxicological analysis of phenylalkylamines are planned and descriptive and problem cases are developed. According to the requirements of the Case study, the purpose of the study and research (situational tasks) is determined, motivated selection of samples for the study - targeted analysis, formation of a research plan with a deadline, systematization of the obtained data (basic or statistical), identification of key strengths of the study using SWOT analysis, predicting potential threats – determining theoretically active toxic metabolites using computer programs for predicting the toxicity of compounds, etc. A comprehensive approach is being developed to study the entire group of compounds with a similar chemical structure while studying each representative of the phenylalkylamine group. The current task remains to improve the educational material on the chemical and toxicological analysis of phenylalkylamines by highlighting the latest methods of analysis and modern chemical modifications of the structure of compounds of the specified group.

LITERATURE REVIEW

Amphetamine-type stimulants (ATS) are a category of psychostimulants. According to their chemical structure, they are classified as phenylalkylamines. Phenylalkylamines include amphetamine, ecstasy, and other substances. Amphetamine abuse is a global modern problem. According to the United Nations Office on Drugs and Crime, an estimated 54 million people worldwide used ATS in 2020. Of these, 34 million used amphetamine and 20 million used ecstasy. In 2021, approximately 60% of amphetamine abuse cases were reported in East and Southeast Asia. Most people who abuse amphetamines are between the ages of 10 and 18. In Iran, 5–12% of high school students have experi-

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enced an amphetamine relapse [Chai et al., 2024; Moran et al., 2024; Ling et al., 2013; World Drug Report, 2020; World Drug Report, 2021; Asante & Atorkey, 2023]. In Thailand, substance abuse has become a serious social problem. Among the Thailand population aged 15 to 24, 39% have used illicit drugs, amphetamines, crystal methamphetamine [Nardilok, 2020; Nagy et al., 2022; Brecht et al., 2000; Dalsgaard et al., 2020; Krass et al., 2021; Saunders et al., 2022].

A serious problem after successful detoxification and rehabilitation in individuals with substance use disorders (SUD) is the high rate of relapse. More than 50% of patients with SUD relapse after treatment and rehabilitation [Rolls, 2013; Ridder, 2017; Brecht et al., 2000]. Studies show that relapse rates range from 40 to 75% and confirm the high relapse rates among ATS users.

Assessing a person's resilience to substance use requires studying risk factors and protective factors to promote successful adaptation. The development of standardized tools to assess «amphetamine resilience» remains important. Screening adolescents undergoing treatment for amphetamine addiction is particularly relevant.

Resilience is viewed as a dynamic process with three components – identification of risk and protective factors for drug use, motivation and making informed decisions against drug use, and skills in applying strategies to curb drug use. This perspective is important for conceptualizing resilience to drug use. There is currently no definitive standard for measuring resilience. The Adolescent Resilience Factor Scale (RFS) is designed to assess protective factors against alcohol use. Such instruments often consider resilience only from an individual perspective and do not capture all possible sources of negative impact on the body. There is a lack of tools to comprehensively measure resilience as a multifactorial concept. The development of such tools expands the possibilities of tailoring individualized care for rehabilitation and relapse prevention in people treated for amphetamine dependence.

Phenylalkylamines are an important group of highly toxic and poisonous substances that are objects of chemical-toxicological analysis [Tsekhmister & Welchinska, 2016; Welchinska et al., 2024]. In order to ensure a comprehensive consideration of phenylalkylamines as objects of chemical-toxicological research in the educational process, it is important to use the Case study method.

With the help of Case study, ways of solving problems of complex study of chemical-toxicological analysis of phenylalkylamines are planned and recommendations for planning research are developed - descriptive and problem cases. The Case study method is a type of problem-oriented learning. It allows you to implement tasks and model an experiment, offer non-standard approaches and find ways to solve the problem. Case study is a broader approach to studying an object [Seawright & Gerring, 2008; Sikora, 1999; Sheremeta & Kanishchenko, 1999].

The research work is intended to generalize, and the conclusions can be related to a larger set or volume. The following analysis methods are used: illustrative applied research, applied research, aggregate applied research, descriptive applied research, instrumental applied research [Koycheva & Yanovskaya, 2023; Joia, 2002; Hellstrom et al., 2005].

Case study allows you to form different research designs: methodological work, single and multiple research designs, "building a realistic picture" design, "anomaly" detection design. These designs are often used in com-

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bination. An effective method is to choose the number of studies and objects that will provide a high expected increase in information. The typology of Case studies includes the definition of objectives, approaches (theoretical justification), choice of processes (single or multiple), choice of study (retrospective, diachronic, parallel, sequential) [Godswill, 2022; Erkan et al., 2023; Pelo et al., 2020; Samuel, 2020; Moskalenko et al., 2011]. Case studies as a form of qualitative research help to inform and make evidence-based decisions in various fields. This approach is valuable for scientific research in the field of health care.

The Case Study method has been successfully transferred to the study of the group of phenylalkylamines using an integrated approach to mastering the various characteristics of these compounds as objects of chemical-toxicological analysis [Nizhenkovska et al., 2020; Welchinska & Nizhenkovska, 2022; Welchinska, 2017; Welchinska & Vilchynska, 2016].

OBJECTIVES

To introduce basic approaches of the Case study method into a comprehensive study of phenylalkylamines as objects of chemical and toxicological analysis during the assimilation of educational material of the discipline «Toxicological and Forensic Chemistry» by students of the Faculty of Pharmacy of the O.O. Bogomolets National Medical University in order to modernize it and increasing the effectiveness of understanding by higher education applicants in higher education institutions of Ukraine in accordance with the educational program (EP) “Pharmacy” of the second (master’s) level of higher education in the specialty I8 “Pharmacy” with the subsequent use of the acquired knowledge in practical activities.

METHODOLOGY

The main stages of studying each class of poisonous and highly toxic substances according to the requirements of the Case study are determining the purpose of the study with the motivation of the need to perform specific studies, motivated selection of samples for study - purposeful, drawing up a study plan and research with setting a deadline, systematization of the obtained data, use of SWOT analysis to predict potential threats to experiments and unplanned changes in work strategy. It is important to predict potential threats - determination of theoretically active toxic metabolites using computer programs for predicting the toxicity of compounds, etc. When teaching the discipline “Toxicological and Forensic Chemistry”, phenylalkylamines are studied according to the following plan: representatives of the group and the peculiarity of their chemical structure, toxicological significance and symptoms of poisoning, objects of study, metabolic pathways and metabolites (active, inactive), isolation methods from research objects, methods for qualitative detection and quantitative determination of phenylalkylamines, antidote therapy.

RESULTS AND DISCUSSION

According to the Case study typology, we used a single- and multiple-research design when studying phenylalkylamines.

Representatives of this group of compound are amphetamines: *amphetamine* (benzedrine, biphetamine, phenylisopropylamine), *methylamphetamine, methamphetamine* («batu», desoxyn, phenylisopropyl-N-methyl-amine hydrochloride), dextroamphetamine (dexamyl, dexedrine), *MDA* (3,4-methylenedioxyamphetamine), *MDMA* («ecstasy», 3,4-methylenedioxymethamphetamine), *MDEA* (3,4-methylenedioxy-N-eth-

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ylamphetamine), *MMDA* (3-methoxy-4,5-methylenedioxyamphe-tamine) and other.

Using and toxicological significance of phenylalkylamines (ATS). Amphetamines – are compounds with structure similar to phenyl ethylamine or phenyl isopropylamine, added side chains promote different levels of catecholamine and serotonine activity. Dextroamphetamine, methylphenidate are used in the treatment of narcolepsy and attention-deficit hyperactivity disorder *(ADHD).* Fenfluramine, dexfenfluramine were used for weight loss but later recalled due to cardiopulmonary toxicity when used in combination with phentermine.

Amphetamines are popular among the persons, poorly adaptable to social conditions, it is difficult to get used to a new lifestyle. These drugs activate the internal excitation mechanisms. Antisocial and schizoid persons prone to abuse of amphetamines. The use of amphetamines is not for medical purpose is typical for individuals seeking to improve their performance. Attempts to reduce the dose to cause drowsiness and depression.

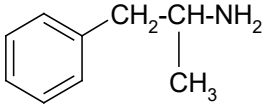
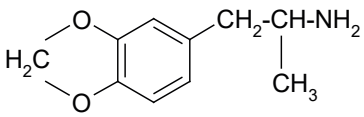
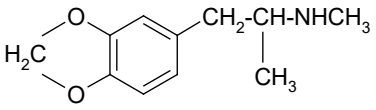
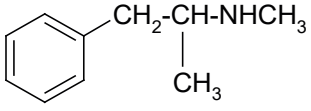
MDMA is a psychoactive amphetamine derivative, when amphetamine abuse observed reactions: dysphoria, tachycardia, hypertension, high blood pressure. *MDMA* is in 1-6 times more potent than mescaline and 1.5–3 times less toxic than *MDA*. Mescaline is a hallucinogenic alkaloid present in peyote that is structurally related to amphetamines and is a 5-HT_2 agonist.

The adverse effects of chronic amphetamine intoxication are anorexia, paranoia, cardiomyopathy, pulmonary hypertension, vasculitis, aortic and mitral regurgitation.

The clinical signs of acute amphetamine intoxication are agitation, anxiety, AMS (altered mental status), mydriasis, hypertension, tachycardia, diaphoresis, tremor, muscle rigidity, hyperthermia, seizures. There is the sympathomimetic toxidrome. Chemical formulas of these medications showed (Table 1).

Table 1. Chemical formulas of phenylalkylamines.

Source: Welchinska, 2017.

ATS	Chemical formula
Amphetamine (benzedrine, biphetamine), (*RS*)-1-phenylpropan-2-amine, Phenyl isopropyl-amine, *D*- and *L*-isomers	
MDA, 3,4-methylenedioxyamphetamine	
MDMA («ecstasy»), 3,4-methylenedioxymethamphetamine	
Methylamphetamine, (methamphetamine, «batu», desoxyn), phenylisopropyl-N-methyl-amine hydrochloride, *D*- and *L*-isomers	

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Metabolism of phenylalkylamines (ATS). Amphetamines bind to the monoamine transportes and increased extracellular levels of the biogenic amines dopamine, norepinephrine and serotonin. Amphetamines metabolized in the liver. These compounds are absorbed in the small intestine, partially bind to proteins, excreted in native form and in the form of metabolites. The biological material for investigation are: internal organs: stomach with its content, intestine with its content, liver, kidneys, spleen; liquids: blood, urine, stomach washings; hair, sweat, nails, saliva.

Persons which reached the state of euphoria, tend to increase the dose of amphetamine with 20–40 mg / day to about 50–150 mg / day. The minimum lethal dose of amphetamine depends on the age and lifestyle of the person. Lethal dose of 1.5 mg / kg (methamphetamine); 0.5–0.7 mcg / ml in blood, 28 mg / kg (amphetamine).

Metabolism for amphetamine and methamphetamine takes place in the liver in the following ways: 1) N-demethylation; 2) oxidation (hydroxylation); 3) dezamination; 2) conjugation (glucuronides, sulphates) (Fig. 1–4):

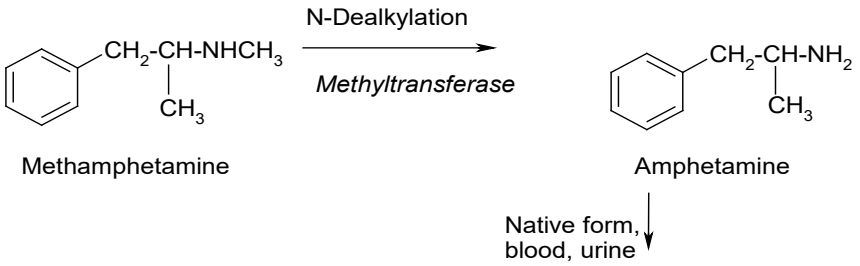

Figure 1. Metabolism of Methamphetamine.

Source: Welchinska, 2017.

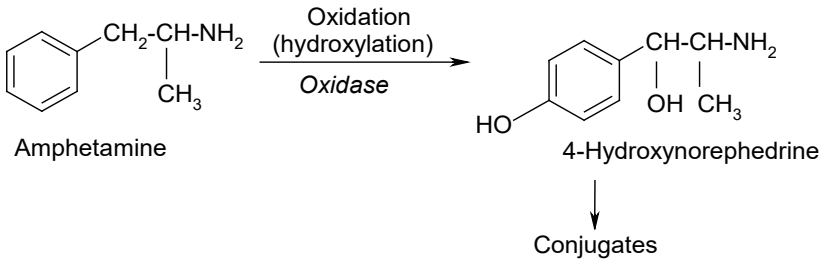

Figure 2. Metabolism of Amphetamine. Source:

Source: Welchinska, 2017.

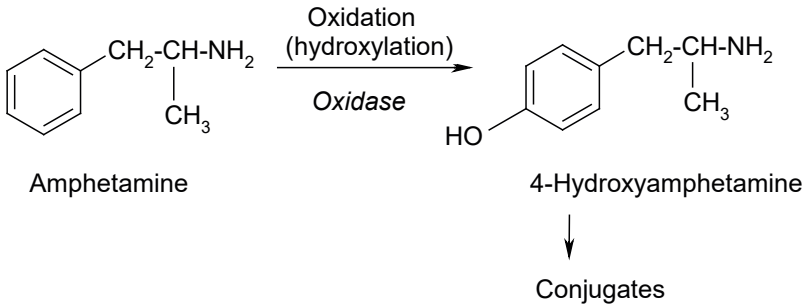

Figure 3. Metabolism of Amphetamine.

Source: Welchinska, 2017.

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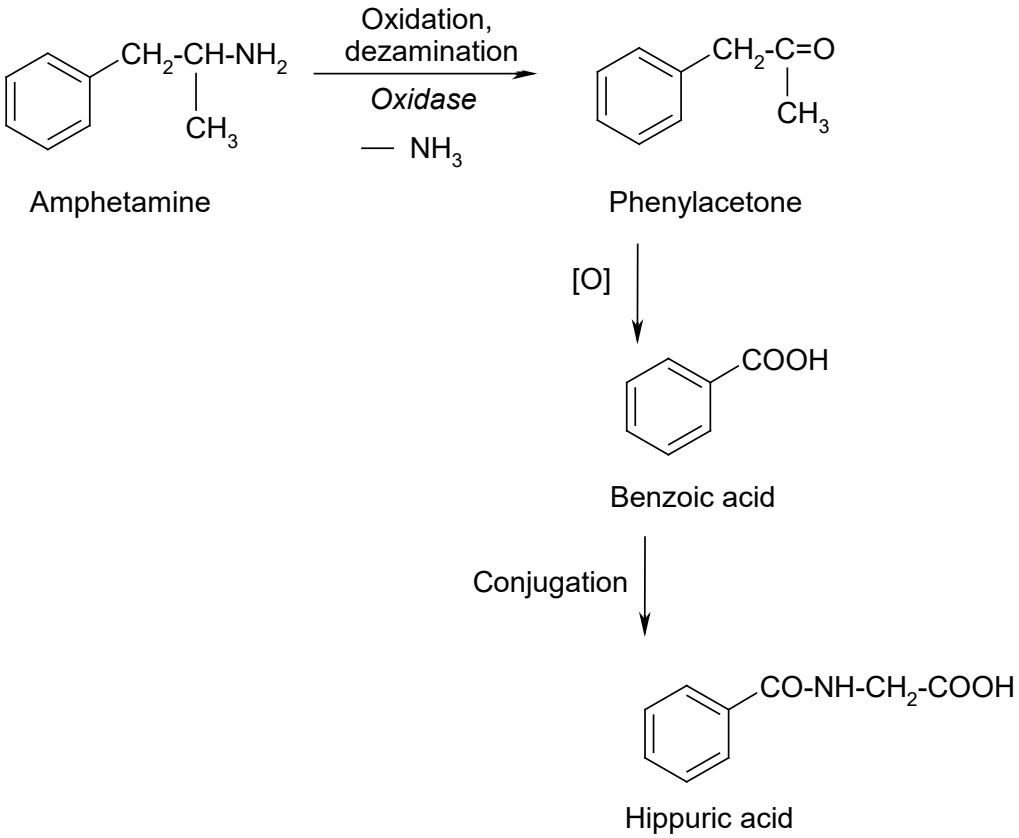

Figure 4. Metabolism of Amphetamine – I and II Phases.

Source: Welchinska, 2017.

Peculiarities of the isolation: amphetamines extracted by organic solvents from aqueous alkaline solutions.

Qualitative analysis. Phenylalkylami-nes (ATS) (Tables 2, 3).

Table 2. Colour tests of qualitative analysis of phenylalkylamines.

Source: Welchinska, 2017.

***Colour tests:* with Marqui's reagent, with Simon's reagent, with Chen's reagent, with gallic acid**
With Marqui's reagent test – allows the distinction between amphetamine and its ring-substituted analogues
With Simon's reagent test – for secondary amines (methamphetamine)
With Chen's reagent test – amphetamine, methamphetamine, *MDA, MDMA* do not react with Chen's test reagent, but it used to distinguish ephedrine, pseudoephedrine, norephedrine
With gallic acid test – provides a simple means for the distinction of *MDMA, MDA, MDEA* from amphetamine or methamphetamine. It reacts specifically with methylenedioxy substituted aromatic compounds

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Table 3. Peculiarities of colour tests of qualitative analysis of phenylalkylamines.

Source: Nizhenkovska, Welchinska & Kucher, 2020.

Reagent	Amphetamine	Methamphetamine	*MDA*	*MDMA*
Marqui's reagent	An orange, slowly	An orange, slowly	A dark-blue → black	A dark-blue → black
Simon's reagent	—	A deep blue	—	A deep blue
Chen's reagent	—	—	—	—
Gallic acid	—	—	A bright to dark green	A bright to dark green
For compare: ***ephedrine*** gives test with Chen's reagent – a purple colour				

Anion tests (the solubility of compounds and their salts in water and solvents systems) (Table 4).

Microcrystallographic reactions:

– Gold chloride test (5 % HAuCl4 in H3PO4):

D- or L-amphetamines – the microcrystals, resembling long yellow rods or coarse needles and long narrow blades;

DL-amphetamine racemate – at first «oily» drops, after – coloured platy crystals;

D-methamphetamines – the «V» blades with one side shorter than the other side;

L-methamphetamines – a single, crossed blades and «v» blades which form characteristic cigar-shaped ends;

DL-methamphetamine racemate – a single and «X» blades which are sometimes «knife»–shaped;

MDMA – a high birefringed white «X»-shaped crystals with star-like clusters under polarized light.

– Test for optical isomers of methamphetamine (H3BiI4 in H2SO4):

D-methamphetamines – a long orange needles;

DL-methamphetamines – an orange-red rods with slanting ends.

Reactions on primary amino group: the reaction of Schiff's bases formation, the reaction of isonitril formation (Fig. 5).

Table 4. Solubility of phenylalkylamines.

Source: Nizhenkovska, Welchinska & Kucher, 2020.

Amphetamine base: slightly soluble in H_2O, methanol, ethanol, diethyl ether, chloroform
Amphetamine hydrochloride: soluble in H_2O, methanol, ethanol, chloroform; insoluble in diethyl ether
Amphetamine phosphate: soluble in H_2O; slightly soluble in methanol, ethanol; insoluble in diethyl ether, chloroform
Amphetamine sulphate: soluble in H_2O; slightly soluble in methanol, ethanol; insoluble in diethyl ether, chloroform

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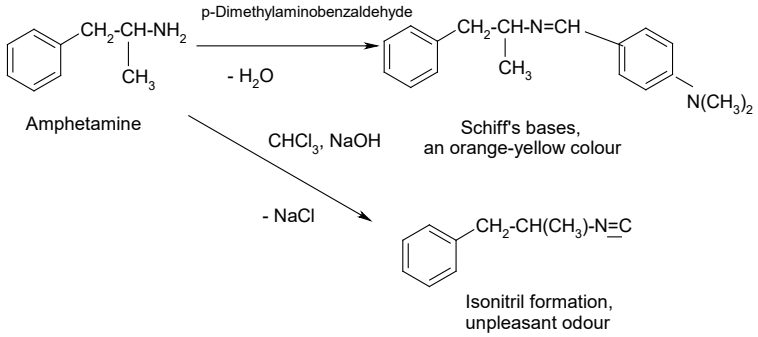

Figure 5. Reactions on primary amino group of Amphetamine.

Source: Welchinska, 2017.

Reactions on benzene ring: the reaction of nitration (Fig. 6).

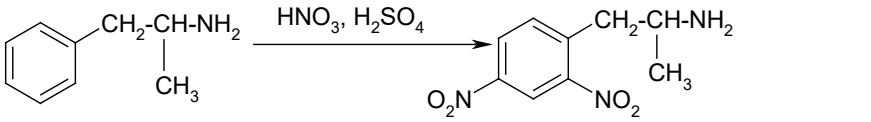

Figure 6. Reactions on benzene ring of Amphetamine.

Source: Welchinska, 2017.

Quantitative determination of amphetamines (*ATS*) is performed by the following physical-chemical methods:

- chromatographic: *TLC, HPLC,* gas chromatography – flame ionization detector *(GC–FID),* gas chromatography – mass spectrometry (*GC–MS),* solid phase-micro extraction – gas chromatography *(SPME–GC),* gas chromatography – Fourier transform infrared spectroscopy *(GC–FIR);*
- spectral: fourier transform infrared spectroscopy (*FTIR),* 1H-nuclear magnetic resonance (*NMR*);
- *capillary electrophoresis (CE).*

Thin layer chromatography (ATS). TLC plates (stationary phases): silica gel G with a layer thickness of 0.25 mm, and containing an inert indicator, which fluoresces under UV light wavelength 254 nm; solvent system or mobile phases (methanol-ammonia conc., 100:1.5; ethyl acetate-methanol-ammonia conc., 85:10:5; cyclohexane-toluene-diethylamine, 75:15:10). *Visualization reagent*: UV light at 254 nm – purple spots on an otherwise green-fluorescent plate; ninhydrin reagent – result in violet or pink spots; acidified potassium iodoplatinate reagent – result in light blue spots; Fast Black K – result in violet to orange or orange-red spots; fluorescamine reagent (Fluram) – result in fluorescence spots.

Gas chromatography – flame ionization detector (GC–FID). Detector: FID (or NPD); column: DB-5 (5 % phenyl 95 % dimethylpolysiloxane), DB-1 (100 % dimethylpolysiloxane); length: 10–30 m, ID 0.20–0.53 mm; film thickness: 0.10–0.50 µm; carrier gas: nitrogen (0.8 ml / min), helium, hydrogen (1–1.2 ml / min for He or H_2); split ratio: 20:1 to 50:1; column temperature: 60–90 °C to 280 °C; injector temperature: 210–250 °C; detector temperature: 310 °C. Identification is accomplished by comparing the retention time of the analyte with that of a reference standard.

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The elution order is as follows: amphetamine < methamphetamine < pseudoephedrine < ephedrine < MDA < MDMA < MDEA < MBDB.

Gas chromatography – mass spectrometry (GC–MS). Operating conditions. GC oven conditions: same as for GC analysis; column: DB-5 (5 % phenyl 95 % dimethylpolysiloxane), DB-1 (100 % dimethylpolysiloxane), 0.25 mm × 30 m × 0.25 *μm*; inlet: mode Split/Splitless (constant flow or pressure), temperature 250 °C, carrier gas helium (1 ml / min); detector: ionisation mode – EI mode, 70 eV (Cl mode if desired), transfer line temperature – 280 °C, ion source temperature – 230 °C, scan parameters – TIC (SIM), scan range 35–450. Identification is accomplished by comparing the retention time and mass spectrum of the analyte with that of a reference standard.

High performance liquid chromatography (HPLC). Operating conditions. Detector: diode array detector (rapid scanning or variable wavelength, UV 200–210 nm); stationary phase: C_8 or C_{18} with 5 μm particle size; column length and diameter: ≤ 30 cm and ≤ 5.0 mm; pre-column: diameter 2–4 mm, length 25 mm, reversed phase C_8 or C_{18}; column temperature 15–35 °C; mobile phase buffer: phosphate buffer pH 2.0–3.2; mobile phase organic modifier: methanol or acetonitrile between 2 % and 20 %; flow rate: 0.1–2.0 ml / min; injection volume 1–100 μm.

Identification is accomplished by comparing the retention time of the analyte with that of a reference standard and by using multiple UV wavelengths or diode array or rapid scanning UV detection.

Capillary electrophoresis (CE). It is similar to *HPLC*, requires no derivatization or extraction steps. In contrast to *HPLC, CE* offers higher resolving power for the analysis of these solutes, which translates into faster analysis.

IR-spectroscopy: in the 800–1600 cm^{-1} region.

^{1}H-nuclear magnetic resonance (*NMR*): enables the analyst to unequivocally distinguish between different ring-substituted amphetamine derivatives; although certain substitution patterns resemble one another in the area corresponding to the protons of the alkyl side chain, the integrated spectrum and the pattern of the aromatic proton singles allow their distinction from one another. Liberate the free base of the *ATS* in situ by the addition of 20–30 mg of solid K_2CO_3 and 0.5 ml CDCl3 and record the spectrum of the free base.

Immunoassays. Radioimmunoassay. Test on reduction of a number of leucocytes.

Antidotes: No antidotes.

Treatment of poisoning by ATS: activated charcoal, benzodiazepines, severe hypertension phentolamin, nitroprusside, Ca antagonists, lidocaine.

After mastering the educational material and based on the results of the research (situational tasks), a laboratory report is compiled and a workbook is filled in. The laboratory report includes the following sections:

- introduction, purpose, objectives of the study;
- justification of the method (methods) used to perform the tasks;
- methods of processing the obtained data;
- results and description of the obtained data, characteristics of the objects of chemical-toxicological analysis, characteristics of the specified physico-chemical parameters or properties of the tested substances;
- discussion of the results obtained, their correspondence to the goal and hypothesis that were the reason for the beginning of the research;
- conclusion on the general result of the learned theoretical material and the per-

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formed practical work and their correspondence to the theoretical materials of literary sources.

CONCLUSIONS

Using the Case study method, we have built an algorithm for learning theoretical material and conducting research on situational tasks of objects of chemical and toxicological analysis of highly toxic substances of phenylalkylamines using the design of single and multiple studies with the identification of «anomalies» and conducting parallel/sequential studies with the comparison of results.

The selection of a large number of objects – derivatives of phenylalkylamines provided a high expected increase in information and results.

The assimilation of the material is carried out according to the following plan: representatives of the group and the peculiarity of their chemical structure, toxicological significance and symptoms of poisoning, objects of study, metabolic pathways and metabolites (active, inactive), isolation methods from objects of study, methods of qualitative detection and quantitative determination of phenylalkylamines, antidote and effective therapy.

Sections of the laboratory report and workbook are filled in based on the results of the work performed.

AUTHOR CONTRIBUTIONS

Conceptualization: Olena Welchinska.
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Validation: Olena Welchinska.
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BIBLIOGRAPHIC REFERENCES

1. Asante, K. O. & Atorkey, P. (2023). Cannabis and amphetamine use among school-going adolescents in sub-saharan Africa: A multi-country analysis of prevalence and associated factors. *BMC Psychiatry*. 23, 778. DOI: 10.1186/s12888-023-05283-w.
2. Brecht, M-L., von Mayrhauser, C. & Anglin, M. D. (2000). Predictors of relapse after treatment for amphetamine use. *J. Psychoact. Drugs.* 32(2), 211–220. DOI: 10.1080/02791072.2000.10400231.
3. Chai, G., Xu, J., Goyal, S., et al. (2024). Trends in incident prescriptions for behavioral health medications in the US, 2018-2022. *JAMA Psychiatry*. DOI: 10.1001/jamapsychiatry.2023.5045.

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4. Dalsgaard, S., Thorsteinsson, E., Trabjerg, B.B. et al. (2020). Incidence rates and cumulative incidences of the full spectrum of diagnosed mental disorders in childhood and adolescence. *JAMA Psychiatry*. 77(2), 155-164. DOI: 10.1001/jamapsychiatry.2019.3523.
5. Erkan, I., Unal, S., Acikgoz, F. (2023).What affects university image and students' supportive attitudes: the 4Q Model. *Journal of Marketing for Higher Education*. 33(2), 205-222.
6. Godswill Agu. (2022). Students' switching intentions for graduate education services: examining the influence of service quality, price, and attractiveness of alternative. *Journal of Marketing for Higher Education*. 30(1), 1-22. DOI: 10.1080/08841241.2022.2101171.
7. Hellström I, Nolan M, Lundh U. (2005). 'We do things together': A case study of 'couplehood' in dementia. *Dementia*, 4(1), 7-22. DOI:10.1177/1471301205049188.
8. Joia (2002). Analysing a web-based e-commerce learning community: A case study in Brazil. *Internet Research*, 12, 305-317. DOI:10.1108/10662240210438434.
9. Koycheva, O.S. & Yanovskaya, L.G. (2023). Vykorystannya metodu Keys vyvchennya yak analizu problemnykh sytuatsiy v istorychniy osviti [Using the Case-study method as an analysis of problem situations in historical education]. *Innovatsiyna pedahohika – Innovative pedagogy. 58(1),* 77-80 [in Ukrainian].
10. Krass P., Dalton, E., Doupnik, S.K., Esposito, J. (2021). US pediatric emergency department visits for mental health conditions during the COVID-19 pandemic. *JAMA Netw Open*. 4(4), e218533. DOI: 10.1001/jamanetworkopen.2021.8533.
11. Ling, W., Mooney, L. & Rawson, R. (2013). Amphetamine-type stimulants. In Addictions: A comprehensive guidebook, *2nd ed.* 174–190. (Oxford University Press).
12. Moran, L.V., Skinner, J.P., Shinn, A.K., et al. (2024). Risk of incident psychosis and mania with prescription amphetamines. *Am J Psychiatry*. DOI: 10.1176/appi.ajp.20230329.
13. Moskalenko, V.F., Nizhenkovska, I.V., Welchinska O.V. (2011). Formuvannya profesiynoyi kompetentnosti maybutn'oho farmatsevta v umovakh kredytno-modul'noyi systemy osvity [Formation of professional competence of a future pharmacist in the context of a credit-modular education system]. *Medychna osvita*. 2, 85-86 [in Ukrainian].
14. Nagy, N. E. S., Ella, E. I. A., Shorab, E. M. & Moneam, M. H. (2022). Assessment of addiction management program and predictors of relapse among inpatients of the Psychiatric Institute at Ain Shams University Hospital. *Middle East. Curr. Psychiatry.* 29, 80.
15. Nardilok, S. (2020). *Statistics on drug abuse treatment in the fiscal year* 2016–2020. Princess Mother National Institute on Drug Abuse Treatment. DOI: www.pmnidat.go.th/thai/index.php?option=com_content&task=view&id=3274&Itemid=53.
16. Nizhenkovska I.V., Welchinska O.V., Kucher M.M. (2020). Toksykolohichna khimiya [Toxicological chemistry]. 3-nd ed. Kyyiv: Medytsyna, 372 +XII p. [in Ukrainian]. http://ek.librarynmu.com/cgibin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULLTEXT&P21DBN=NMU&Z21ID=&S21CNR=5.
17. Pelo, I.M., Reva, T.D., Nizenkovska, I.V., Kozak, N.D., Konovalova, L.V. (2020). Trends in the professional training of pharmacy specialists in Ukraine. *Medicni Perspektivi*. 25(3), 4-8. DOI: 10.26641/2307-0404.2020.3.214543.
18. Ridder, H.G. (2017). The theory contribution of case study research designs. *Business Research.* 10, 281–305.DOI: 10.1007/s40685-017-0045-z.
19. Rolls, G. Classic Case Studies in Psychology. (2-nd ed.) (2013). Abingdon, England: Hodder Education, 24-110. DOI: 10.4324/9780203783900.
20. Samuel, R. (2020). Basic Concept of Chemistry. *CXC Chemistry Rockella.* 25 p. DOI: 10.1371/JOURNAL.0148257.
21. Saunders, N.R., Kurdyak, P., Stukel, T.A. et al. (2022). Utilization of physician-based mental health care services among children and adolescents before and during the COVID-19 pandemic in Ontario, Canada. *JAMA Pediatr.* 176(4), e216298. DOI: 10.1001/jamapediatrics.2021.6298.
22. Seawright, J. & Gerring, J. (2008). Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. *Political Research Quarterly*, 61(2), 294-308. DOI: 10.1177/1065912907313077.
23. Sheremeta, P. M. & Kanishchenko, L. G. (1999). *Keys-metod: z dosvidu vykladannya v ukrayins'kiy biznes-shkoli [Case method: from the experience of teaching at a Ukrainian business school].* 2-nd ed. Kyyiv: Tsentr innovatsiy ta rozvytku, 80 p. [in Ukrainian].

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24. Sikora, Ya. B. (1999). Keys-tekhnolohiyi pry vyvchenni «Metodiv optymizatsiyi» [Case technologies in the study of «Optimization Methods»]. Proceedings from: *Naukovo-doslidna robota molodykh uchenykh: stan, problemy, perspektyvy: Materialy II Vseukrayins'koyi naukovo-praktychnoyi internet-konferentsiyi, prysvyachenoyi 95-richchyu Khersons'koho derzhavnoho universytetu – Research work of young scientists: status, problems, prospects: Materials of the II All-Ukrainian scientific and practical Internet conference dedicated to the 95th anniversary of Kherson State University.* (pp.244-248). Kherson [in Ukrainian].
25. Tsekhmister, Y. & Welchinska, E. (2016). Carbon (II) monoxide as a subject for poisons studying of study on discipline toxicological chemistry (criminal analysis) at the pharmaceutical department of the National Medical University in Ukraine. *CBU International conference proceedings 2016: Innovations in Science and Education*. 4, 744-749. DOI: 10.12955/cbup.v4.843.
26. United Nations Office on Drugs and Crime. *World drug report 2020*. (2022). United Nations Office on Drugs and Crime. DOI: wdr.unodc.org/wdr2020/field/WDR20_Booklet_2.pdf
27. United Nations Office on Drugs and Crime. *World drug Report 2021* (United Nations Office on Drugs and Crime, 2023).
28. Welchinska, O.V. (2017). Toxicological chemistry (Criminal analysis). Kyiv: Lopatina, 392 p.
29. Welchinska, O.V., Nizhenkovska, I.V. (2022). Toksykolohichna ta sudova khimiya [Toxicological and Forensic Chemistry]. 3-nd ed. Kyyiv: Lopatina, 332 p. [in Ukrainian]. http://ek.librarynmu.com/cgibin/irbis64r_plus/cgiirbis_64_ft.exe?C21COM=F&LNG=uk&I21DBN=NMU_FULLTEXT&P21DBN=NMU&Z21ID=&S21CNR=5.
30. Welchinska, O., Nizhenkovska, I., Meleshko, R. (2024). Suchasni pidkhody do farmatsevtychnoho analizu metodom *VERKH* alkaloyidu paklitakselu [Modern approaches to the pharmaceutical analysis by HPLC of paclitaxel alkaloid]. *Fitoterapiia. Chasopys – Phytotherapy. Journal*. 3, 168–174, DOI: 10.32782/2522-9680-2024-3-168.
31. Welchinska, E., Vilchynska, V. (2016). New compound N1,N1'-(2»-bromo-2»-chloroethenyl)-bis-(5-fluorouracil) as the active antitumor agent for sarcoma 180. *CBU International conference proceedings 2016: Innovations in Science and Education,* 4, 740-743. DOI 10.12955/cbup.v4.842

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