FORENSIC INVESTIGATION OF METHAMPHETAMINE TABLETS USING PHYSICAL AND CHEMICAL PROFILING

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FORENSIC INVESTIGATION OF METHAMPHETAMINE TABLETS USING PHYSICAL AND CHEMICAL PROFILING

by

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LIST OF ABBREVIATIONS, SYMBOLS AND ACRONYMS

%	Percentage
±	Plus–minus
°C	Degree Celsius
°C/min	Degree Celsius per minute
µL	Microliter
µm	Micrometer
ATR	Attenuated total reflectance
ATS	Amphetamine-type simulant
cm	Centimeter
D&C	Drugs and cosmetics
DAD	Diode-array detector
DEA	Drug Enforcement Administration
et al.	*et alia* – and others
F	Fluorine
FID	Flame ionisation detector
FTIR	Fourier transform infra-red
HPLC	High performance liquid chromatography
HPLS	Hierarchical partial least squares
g	Gram
GC	Gas chromatography
GC-MS	Gas chromatography-mass spectrometry
i.d.	Internal diameter
i.e.	*id est* – that is
IR	Infrared
L	Liter
m/z	Mass-to-charge
min	Minute
mg	Milligram

mg/mL	Milligram per milliliter
mL	Milliliter
mL/min	Milliliter per minute
mol	Mole
mm	Millimeter
M	Molar
MDMA	3,4-Methylenedioxymethamphetamine
MSD	Mass spectrometry detector
NPS	New psychoactive substances
NIST	National Institute of Standard and Technology
p	*p*-value
PC	Principal component
PCA	Principal component analysis
PDA	Photodiode array
PLS	Discriminant analysis
QC	Quality control
R^2	Regression coefficient
RSD	Relative standard deviation
SD	Standard deviation
TLC	Thin layer chromatography
UNDCP	United Nations Drug Control Programme
UNODC	United Nations Office of Drugs and Crimes
UV	Ultraviolet
v	Volume

PENYIASATAN FORENSIK TABLET METAMFETAMIN MENGGUNAKAN PEMPROFILAN FIZIKAL DAN KIMIA

ABSTRAK

Rampasan tablet metamfetamin haram telah mencapai satu tahap rekod yang tinggi di seluruh dunia dan penggunaannya secara meluas telah mengancam kesejahteraan masyarakat. Justeru, perhatian daripada pelbagai pihak sangat diperlukan untuk membendung pengedaran metamfetamin. Secara umumnya analisis rutin forensik terhad dalam mengenal pasti dan menentukan kuantiti bahan terkawal berdasarkan prosedur operasi standard yang telah ditetapkan. Oleh kerana pencirian analitikal dan pemprofilan dadah tersebut melalui kaedah fizikal dan kaedah kimia tidak dilaksanakan secara rutin, maka kajian lanjut dilaksanakan demi perbandingan dan perisikan forensik. Dalam kajian ini, penilaian profil fizikal dan profil kimia ke atas tablet metamfetamin haram daripada kes-kes terkumpul melalui pelbagai teknik analitikal, termasuk pemeriksaan fizikal, kromatografi lapisan nipis (TLC), spektroskopi transformasi inframerah fourier dengan pantulan keseluruhan dikecilkan (ATR-FTIR) dan akhirnya kromatografi gas (GC). Keputusan analitikal telah dibandingkan dan dinilai untuk kemungkinan pembezaan. Secara umum, pencirian fizikal tidak dapat mengenal pasti metamfetamin dengan hanya enam sampel dibezakan daripada kumpulan utama melalui logo yang unik dan dimensi. Tablet dengan logo “wY” telah menguasai sampel tersebut (94.5%) dan kebanyakannya telah diukur dengan diameter antara 6.01 dan 6.20 mm (74.1%). Analisis TLC menentukan Ponceau 4R sebagai pewarna utama yang

ditambahkan ke dalam kandungan tablet tersebut (95.6%), manakala analisis ATR-FTIR dan analisis PCA menunjukkan kafien merupakan komponen utama bahan adukan dalam kebanyakan sampel (99.4%). Akhirnya, teknik GC mengenal pasti kehadiran metamfetamin melalui perbandingan spektrum jisim dengan indeks kesamaan melebihi 80% (98.8%) dan ketulenannya telah ditentukan. Kesimpulannya, satu strategi pemprofilan tablet metamfetamin telah dilaksanakan untuk pengumpulan maklumat berkenaan kesamaan dan perbezaan antara tablet metamfetamin haram. Hal ini berpotensi dalam memanfaatkan perbandingan sampel kepada sampel, kes kepada kes, dan rampasan kepada rampasan.

FORENSIC INVESTIGATION OF METHAMPHETAMINE TABLETS USING PHYSICAL AND CHEMICAL PROFILING

ABSTRACT

Illicit methamphetamine seizures have reached record levels worldwide and its widespread use threatens societal well-being. Thus, attention from various parties is required to stem methamphetamine trafficking; however, routine forensic analysis is generally limited to identifying and quantifying the controlled substances according to standard operating procedures. Although further analytical characterization and drug profiling via physical and chemical methods is not routinely conducted, it warrants further exploration for forensic comparison and intelligence. In this study, evaluation of physical and chemical profiles of illicit methamphetamine tablets collected from case work was carried out through various analytical techniques, including physical examination, thin layer chromatography (TLC), attenuated total reflectance-Fourier transformed infrared (ATR-FTIR) spectroscopy, and lastly gas chromatography (GC). The analytical outputs were compared and evaluated for possible discrimination. Generally, physical characterisation did not enable the identification of methamphetamine with only six samples were discriminated from the main cluster through their unique logos and dimensions. Tablets with logo "wY" dominated the samples (94.5%), and majority of them were measured between 6.01 and 6.20 mm in diameter (74.1%). ATR-FTIR coupled with PCA suggested caffeine as adulterant in majority of the samples (99.4%), while TLC analysis determined that Ponceau 4R was

the major dye added into the composition of the tablets (95.6%). Lastly, the GC technique confirmed the presence of methamphetamine (98.8%) through mass spectral comparison with similar index greater than 80% and the purity was determined. In conclusion, a methamphetamine tablet profiling strategy was implemented to gather important information regarding the similarities and differences among illicit methamphetamine tablets, potentially beneficial for sample-to-sample, case-to-case, and seizure-to-seizure comparisons.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Narcotic substances are chemicals which carry an effect towards the body and mind, and potentially lead to physical and/or psychological dependence. In the context of international level drug control, it refers to any substances, either natural or synthetic, that are categorised in the Schedules I and II of the Single Convention on Narcotic Drugs 1961, and in the Convention on Psychotropic Substances of 1971 (UNODC, 2016). The former regulation aims to fight the misuse of illicit drug through international and collaborative actions, where it listed the intervention and control to limit the possession, use, trade in, distribution, import, export, manufacture, and production of drugs exclusively to medical and scientific purposes, as well as to combat drug trafficking and smuggling activities through international cooperation and collaboration. On the other hand, the latter establishes the control of psychotropic substances based on the therapeutic use and the public health risk of these substances. Note that the methamphetamine is listed in the Schedule II of the Convention on Psychotropic Substances of 1971 (UNODC, 2021a). Classification in Schedule II indicates that methamphetamine possesses the risk of abuse, carrying a severe threat to the public health, and is of low or moderate therapeutic value (UNODC, 2016).

Amphetamine-type stimulants (ATS) refer to a group drugs where the key members are amphetamine, methamphetamine, and 3,4-Methylenedioxy methamphetamine (MDMA). The MDMA is more commonly named as ecstasy. ATS are mostly synthetic in nature, and they are grouped due to their stimulant effects, excluding them from the groups of cocaine, nicotine, and some herbal stimulants (WHO, 1997; UNODC, 2016). ATS possess the stimulatory effect towards the central nervous system of the drug users, greatly influencing the actions and levels of neurotransmitters such as dopamine, norepinephrine, and serotonin (UNODC, 2016). In this study, the illicit methamphetamine tablets were tested and analysed, and they produce alertness and elation as demonstrated in the substances under the classification of ATS.

In the past two decades, a rising trend problems related to methamphetamine was reported where its global seizure had increased sevenfold (UNODC, 2020a; UNODC, 2020b). Although strict punishments had been imposed on the drug manufacturers, smugglers, distributors, and the users, the increase in term of the misuses of such illicit drug had been reported in many countries, including the United States, Europe, Australia, and New Zealand. It was also reported that the statistics on the abuse of illicit methamphetamine in East and South-East Asia remains widespread for the past many years, where the countries within these regions had contributed to more than 30% of the worldwide estimated users of ATS (UNODC, 2020a). The numbers had suggested the severity of the drug problems, specifically illicit methamphetamine which needs immediate action domestically and internationally.

Illicit methamphetamine drugs are mainly produced in the clandestine laboratories. In recently years, domestic methamphetamine manufacturing activities in the United States, China, and Islamic Republic of Iran were said to be reduced sharply with decreased number of dismantled clandestine laboratories (UNODC, 2020a). However, the significant expansion on the trafficking of illicit methamphetamine was reported in Mexico, as well as East and Southeast Asia (UNODC, 2020a), suggesting the gradual shift of the black market of the drug from North America to the East and Southeast Asia. In our country, a sharp increase in seized methamphetamine since 2015 was reported. In a single year of 2019, approximately 5.8 tonnes of crystalline methamphetamine were encountered by the law enforcement authorities in addition to more than 1.6 million illicit methamphetamine tablets. It is important to note that the successful detection rate would not be 100% where part of these illicit drugs could have entered the black market. In view of this, and the amount of illicit drugs available for abuse shall be in a far greater number. Besides distributed within the country domestically, Malaysia has also been known as the transportation hub in Southeast Asia where illicit drugs are further trafficked and distributed to the neighbouring countries in the region, as well as to the Oceania region, including Australia and New Zealand (UNODC, 2020a).

Based on the statistics released by UNODC (2020a), a total of 139 clandestine laboratories were detected and dismantled in Malaysia from 2015 to 2019. Amongst, 57 of them were involved in the production of illicit methamphetamine. In the country, several cases of large-scale methamphetamine clandestine laboratories were also dismantled, and such cases had alarmed the law enforcement authorities and the forensic communities. Recent statistics and trend analysis showed that the expansion of methamphetamine black market in the East and Southeast Asia has been highly driven by supply, where the methamphetamine trafficking routes had been adapted by the organised crime groups in response to law enforcement operations (UNODC, 2020a). The growing methamphetamine manufacture in the region was supported by the rise in the diversion and trafficking of precursors and related chemicals (UNODC, 2020a). Illicit methamphetamine drugs were also recently sold at cheaper price and directly increased the affordability of such illicit drug in the region, indicating reduced production costs and shift in business model of the drug syndicates (UNODC, 2020a). To track the distribution networks of the illicit drugs, as well as links of suppliers, distributors and users, drug profiling involving characterisation of seized illicit drug samples in a systematic way shall be conducted. Through the physical and chemical means of the illicit drug testing, the outcome could potentially aid in supporting the forensic intelligence, particularly for the law enforcement authorities and forensic science communities.

1.2 Problem Statement

Methamphetamine can appear in various forms, either as an oily paste consisting of methamphetamine free-base, or as a solid which is the methamphetamine in salt form. The high-purity methamphetamine salt can appear in crystalline form, commonly termed as “crystal” or “ice” (National Institute on Drug Abuse, 2019). Methamphetamine is also commonly processed into tablet form known as “*Yaba*” tablets in Asia, especially in the golden triangle region bounded by Thailand, Laos, and Myanmar. Today, the manufacturing, trafficking and abuse of illicit methamphetamine is a serious global problem (UNODC, 2020a; UNODC, 2020b). Countries such as Malaysia, Australia, and China are inundated by transnational drug trafficking (Libby, 2018). Transnational efforts to identify and disrupt the supply chain are therefore crucial.

In routine forensic analysis, testing is frequently limited to identifying and quantifying the controlled substance in the illicit drug sample. However, limited information is retrieved regarding the source of origin, and the supply, trafficking, and distribution network thereof without further post-seizure profiling studies. Studies focused on the profiling of methamphetamine have been conducted, generally employing gas chromatographic techniques (Sennello, 1971; Puthaviriyakorn *et al*, 2002; Mitrevski and Zdravkovski, 2005). However, analytical characterisation *via* physical and chemical methods is less likely to be conducted in forensic laboratories, and therefore gathering further information is required for subsequent forensic comparisons and intelligence.

In non-ideal clandestine laboratory production, the chemical composition of illicit drugs can vary significantly. To elucidate the connection between suppliers, distributors, and users, illicit drug profiling involving the characterisation of seized samples in a systematic manner should be conducted (UNODC, 2001). In this study, the physical and chemical profiles of illicit methamphetamine tablets were investigated employing various analytical techniques. Such an integrated approach for profiling illicit drugs could potentially support forensic intelligence (UNODC, 2001; Esseiva *et al*., 2003; Dufey *et al*., 2007), and be particularly useful for law enforcement authorities.

1.3 Scope of the Study

As described in Section 1.2, the routine analysis of methamphetamine tablets in the forensic laboratories involved the physical examination to determine their possible identities and subsequently by GC technique to confirm and quantify the active compound. In this study, such analyses were carried out according to the standard operating procedure established by the Department of Chemistry Malaysia, with additional investigation on the detail physical characteristics as well as the attenuated total reflectance-Fourier transform infra-red spectroscopy (ATR-FTIR) and thin layer chromatography (TLC). In this study, the tested samples were those samples submitted to the forensic laboratory over a duration of 26 months from July 2017 and August 2019.

1.4 Aim and Objectives

This study was aimed to characterise the illicit methamphetamine tablets for forensic investigation of drug related cases. To achieve the aims, three objectives were set as follows:

i. To examine the physical characteristics of illicit methamphetamine tablets from different seizures.

ii. To evaluate the chemical profiling of illicit methamphetamine tablets through TLC, ATR-FTIR, and GC techniques.

iii. To discriminate illicit methamphetamine tablets through physical characterisation and chemical profiling.

1.5 Significance of the Study

The establishment and implementation of a methamphetamine tablet profiling strategy allowed the law enforcement authorities to gather important information regarding the similarities and differences among illicit methamphetamine tablets, potentially beneficial for sample-to-sample, case-to-case, and seizure-to-seizure comparisons. Subsequently, it would benefit the forensic intelligence, to certain extent, predicting the possible source of production and distribution link. This study could also provide the important knowledge on the profiles of illicit drug in Malaysia, which requires the full collaboration of national and international law enforcement teams, governments, community, and forensic laboratories.

CHAPTER TWO

LITERATURE REVIEW

2.1 Methamphetamine – Amphetamine Type Stimulant

The history of methamphetamine can be traced back to amphetamine, a type of stimulant drug first synthesised by a Romanian chemist named Lazar Edeleanu at the University of Berlin in 1887 (MethOIED, 2021). Initially, it was used for several purposes, including as an amphetamine-based inhaler with a trade name of Benzedrine to treat nasal congestion, and for ailments such as rhinitis and asthma. With an additional methyl group attached to the amine group, methamphetamine (or methylamphetamine) was first synthesised from ephedrine in 1893 by a Japanese pharmacologist named Nagayoshi Nagai (Nagai and Kamiyama, 1988). Historically, it did not become widely used and abused as we see today until World War II when Japan, Germany, and the United States provided the methamphetamine to military personnel as prescription to boost their endurance and performance (Anglin et al., 2000).

Methamphetamine is designated as CAS-537-46-2 (CAS, n.d). Note that CAS is a unique numerical identifier number assigned to a chemical substance by the Chemical Abstracts Service. This is a body responsible for indexing chemistry-related literature and patents in the world. Chemically, methamphetamine is a member of the phenethylamine family. In brief, phenethylamine refers to a chemical substance consisting of a phenyl group attached to a linear two-carbon-atoms chain and terminating in an amino group. The expanded name for phenethylamine is 2-

phenylethylamine, and therefore methamphetamine can also be named as N,α-dimethylphenethylamine (EMCDDA, 2021).

According to International Union of Pure and Applied Chemistry (IUPAC), methamphetamine is named as N-methyl-1-phenylpropan-2-amine, and its chemical structure is demonstrated in Figure 2.1. IUPAC is an international body responsible for the systematic nomenclature of chemical entities.

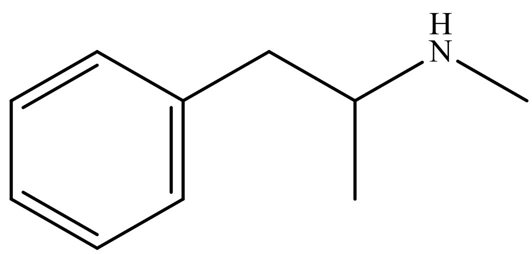
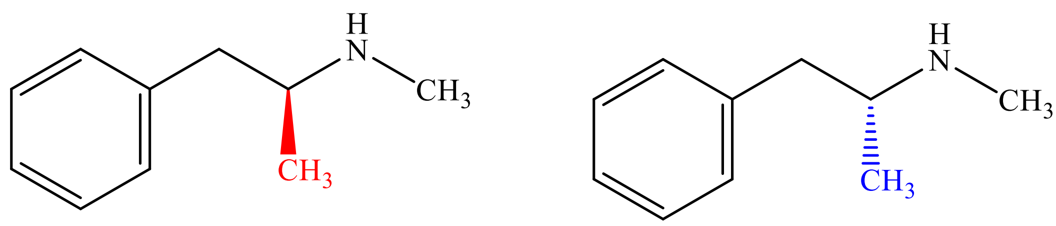


Figure 2.1: Chemical structure of methamphetamine.

As shown in Figure 2.1, due to the asymmetric α-carbon atom, the chemical structure can give rise to two enantiomers, namely the [–]- or l-stereoisomer and the [+]- or d-stereoisomer. However, it is more common now to designate the two different 3-dimensional forms as the R- and S-stereoisomers, as shown by the wedged bond (indicates the bond is projecting out towards the viewer, as marked red in the chemical structure on the left) and a hashed bond (broken wedge indicates this bond is receding away from the viewer, as marked blue in the structure on the right) as illustrated in Figure 2.2. Amphetamine with structural similar to methamphetamine without a methyl group in the amine also gives its R- and S-Amphetamine stereoisomers as shown in Figure 2.3.



S(+)-Methamphetamine
D-Methamphetamine
Dextromethamphetamine

R(-)-Methamphetamine
L-Methamphetamine
Levemethamphetamine

Figure 2.2: Structures of R- and S-Methamphetamine stereoisomers.

S(+)-Amphetamine
D-Amphetamine
Dextroamphetamine

R(-)-Amphetamine
L-Amphetamine
Leveamphetamine

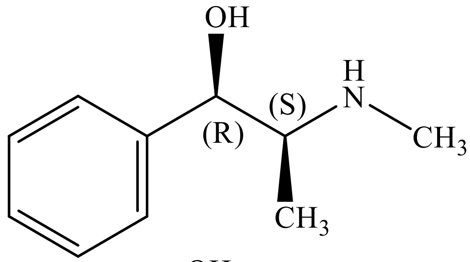
Figure 2.3: Structures of R- and S-Amphetamine stereoisomers.

In general, D-enantiomer has greater biological activity than the L-enantiomer for both amphetamine structures (Sigma-Aldrich, 2021). It is important to note that amphetamine and methamphetamine, together with methcathinone, fenethylline, ephedrine, pseudoephedrine, methylphenidate and MDMA or Ecstasy, are commonly grouped and termed as ATS (WHO, 2021). This term has been used widely by World Health Organisation (WHO) and forensic science communities.

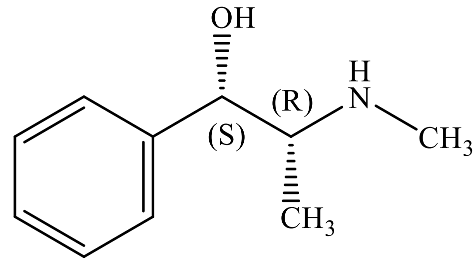
It is vital to mention about the structure of ephedrine and pseudoephedrine, which are closely related to methamphetamine cases, especially in the clandestine methamphetamine laboratories scenes as the precursors. Ephedrine exhibits optical isomerism with two chiral centres. This allows ephedrine to be arranged into four stereoisomers, namely (a) (-)-erythro-Ephedrine, and (b) (+)-erythro-Ephedrine with the pair of enantiomers with the stereochemistry (1R,2S) and (1S,2R) collectively known as ephedrine. The structure in (c) is the (+)-threo-Ephedrine and (d) is the (-)-threo-Ephedrine from the pair of enantiomers with the stereochemistry (1R,2R) and (1S,2S) conventionally known as pseudoephedrine. The four above-mentioned stereoisomers are shown in Figure 2.4.

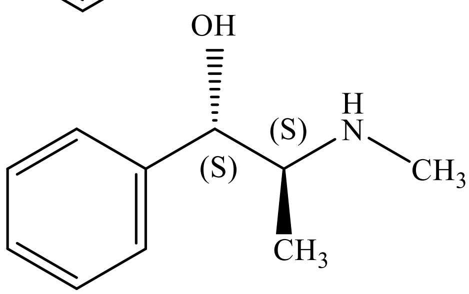
As seen Figure 2.4, the chemical structures of (1R, 2S)-(-) Ephedrine [Figure 2.4 (a)] and (1S,2S)-(+) Pseudoephedrine [Figure 2.4 (c)] are S(+)-Methamphetamine analogues. The only difference between the structures is the absence of a hydroxyl group (-OH) in methamphetamine [Figure 2.4 (e)]. This explains why (-) ephedrine and (+) pseudoephedrine are commonly found in clandestine methamphetamine laboratories as precursors, where clandestine chemists used various methods to remove the -OH group to form methamphetamine.

(a) (1R,2S)-(-)-Ephedrine
(-)-erythro-Ephedrine

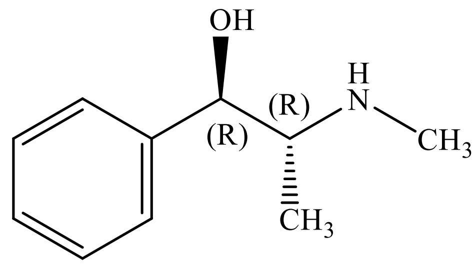


(b) (1S,2R)-(+-Ephedrine
(+)-erythro-Ephedrine

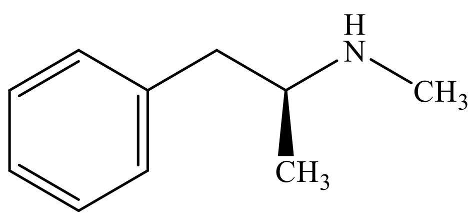




(c) (1S,2S)-(+)-Pseudoephedrine
(+)-threo-Ephedrine



(d) (1R,2R)-(-)-Pseudoephedrine
(-)-threo-Ephedrine



(e) S(+)-Methamphetamine

Figure 2.4: Structures of ephedrine which consists of four stereoisomers, namely (a) (-)-erythro-Ephedrine, (b) (+)-erythro-Ephedrine known as ephedrine; and (c) (+)-threo-Ephedrine and (d) (-)-threo-Ephedrine known as pseudoephedrine, when compared to the structure of S(+)- Methamphetamine.

2.2 Forms of Methamphetamine

Methamphetamine can present in many forms (EMCDDA, 2021). In terms of chemical forms, it can appear in the forms of methamphetamine free base, methamphetamine salt such as methamphetamine hydrochloride, or methamphetamine sulphate. In the form of methamphetamine free base, the molecular formular is $C_{10}H_{15}N$ with a molecular weight of 149.23 g/mol. Its pure form appears as clear, colourless liquid, which is soluble in both ethanol and diethyl ether. In water, its solubility is 0.5 g/mL (PubChem, 2021a). In terms of pH, a saturated solution of methamphetamine base in water is alkaline turning red litmus to blue (PubChem, 2021a). In the salt form, methamphetamine hydrochloride is $C_{10}H_{15}$ N.HCl with a molecular weight of 185.69 g/mol (PubChem, 2021b). It appears as white solid in its pure form, and soluble in both water and ethanol (Sigma Aldrich, 2021b). Methamphetamine sulphate has a molecular formula of $C_{10}H_{17}NO_4S$ with a molecular weight of 247.31 g/mol (PubChem, 2021c). Nonetheless, not much information regarding the characteristics of the sulphate form is available.

In the forensic scenes, methamphetamine can appear in different forms based on its physical characteristics. Appearing as powder form in white or off-white colour, it is known with different name, such as ‘speed’ in Australia (McKetin and McLaren, 2004). The powder form is very common in the clandestine laboratories and to the users. Such fine powder is often snorted, swallowed, smoked, or even injected if dissolved (MethOIED, 2021). Therefore, it is dangerous if the powder is contaminated with toxic impurities, since methamphetamine powder could have been adulterated with other substances such as glucose, caffeine, or ketamine. It was also important to note that methamphetamine can appear in the form of damp or oily substance with a white, yellow, or brown colour appearance. With this, it could likely be in its base form. Unlike the powder form that could have been added with cutting agent, methamphetamine base that is known by “paste” and “wax” might be taken *via* injection or directly swallow it (McKetin and McLaren, 2004).

In the recent years, the crystalline substance of illicit methamphetamine had been reported, especially in Asia and Southeast Asia countries where there was an increase in supply of crystalline methamphetamine (UNODC, 2020c). Also known as “ice” or “crystal” which was reported to be technologically originated from Taiwan and Korea, it was subsequently adapted by the clandestine chemists in the United States to produce the illicit products (Cho, 1990). As reflected by its name, “ice” is of translucent to white appearance. Crystalline methamphetamine is of high purity and therefore, when compared to other forms of methamphetamine, it is the most potent form of methamphetamine. It is commonly injected into the body by the drug users (McKetin and McLaren, 2004).

Methamphetamine also appears in the form of tablets or commonly termed as methamphetamine tablets or the *“Yaba”* tablets (commonly known in Thailand). In Malaysia, it was called as *“pil kuda”*. The round tablets, often red or orange, containing methamphetamine, might have been mixed with other compounds, such as caffeine of ketamine (McKetin and McLaren, 2004). In most instances, they may carry logos on the tablets, such as the symbols of R and WY (National Drug Intelligence Centre, 2003), OK, 888 (Adam et al., 2005), or K, A, Y, 88 and V8 (Li et al., 2017).

2.3 Trends of Methamphetamine Situation

According to UNODC, it was estimated to have around 27 million people worldwide (*i.e.* 0.5 % of the adult population) have used amphetamines, including amphetamine, methamphetamine and pharmaceutical stimulants in 2019 (World Drug Report, 2020a). UNODC also reported that there are variations of regions and subregions in term of amphetamines use, where methamphetamine is most prevalent in the North America, East and Southeast Asia, as well as the Oceania countries. However, it was noted that amphetamine is more prevalent in the Western and Central Europe, as well as the Near and Middle East (UNODC, 2020b).

UNODC has indicated a few general trends of methamphetamine situation globally. In general, the quantity of ATS (where majority of them are methamphetamine, some amphetamine and ecstasy) seized globally has increased over the period 2009–2018 (Note that the quantity of ATS seized has quadrupled) mainly attributed by sevenfold increase of methamphetamine (UNODC, 2020b). In 2018, the United States, Thailand and Mexico are the top three countries responsible for most of the methamphetamine seized worldwide. It was also seen that the global methamphetamine market is expanding, where North America and East and Southeast Asia countries remain to be the major markets (UNODC, 2020a; UNODC, 2020b).

2.3.1 Methamphetamine Situation in Asia Region

In Asia region, according to UNODC, methamphetamine tablets and crystals were reported to been largely produced from the "Golden Triangle" and distributed to Mekong regions and Southeast Asia countries *via* different trafficking routes to other countries (UNODC, 2019; ThermorFisher, 2020). Figure 2.5 shows the perceived methamphetamine tablet trafficking flows in the Mekong region, where Thailand has become one of the main route for the entry of methamphetamine tablets into Malaysia (UNODC, 2019).

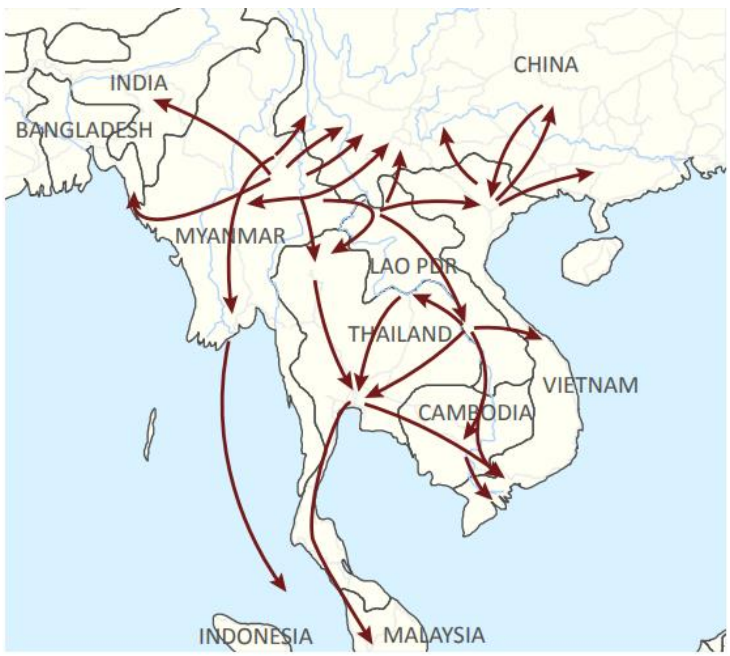


Figure 2.5: Perceived methamphetamine tablet trafficking flows in the Mekong region (Source: UNODC, 2019).

As reported by UNODC (2020b), the Golden Triangle has recently become the "epicentre" for illicit methamphetamine seen in the East and Southeast Asia countries, as well as to the Oceanian countries including Australia and New Zealand. In addition to heroin and methamphetamine tablets, the data from the cases seized also indicated that the illicit manufacturers in the Golden Triangle regions have also recently shifted to produce the purer form of crystalline methamphetamine and other synthetic drugs. Figure 2.6 shows the changes in the seizure of methamphetamine tablets and crystalline methamphetamine in Southeast Asia from 2014-2019, indicating that the amount (in kg) of methamphetamine crystals had increased sharply especially after 2016.

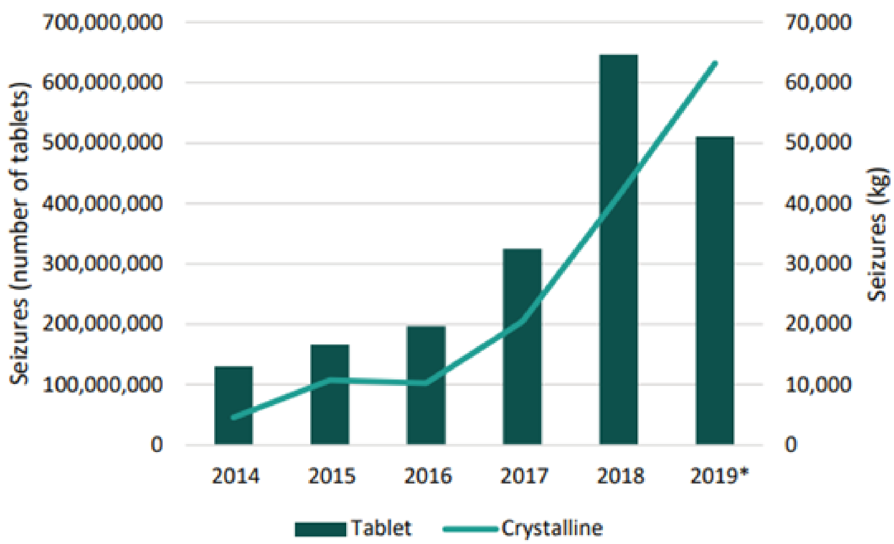


Figure 2.6: Changes in the seizure of methamphetamine tablets and crystalline methamphetamine in Southeast Asia from 2014-2019 (Source: UNODC, 2020b. Note * - data may change based on updates).

2.3.2 Methamphetamine Situation in Malaysia

Malaysia has been mentioned very frequently in UNODC reports on several mega cases of clandestine methamphetamine laboratories as well as drug smuggling and trafficking activities. Several factors have contributed to the prevalence of methamphetamine tablets in Malaysia, especially in the Kelantan State, partly due to its proximity to the neighbouring country, separated by a narrow river called Sungai Golok where the source of the tablets could have come from (BH Online, 2019), see Figure 2.7.

Figure 2.7: Sungai Golok – a narrow river that separates Kelantan State from the neighbouring country (Source: BH Online, 2019).

The degree of problems of methamphetamine tablets could be reflected by the statement given by the Kelantan State Police Chief, Datuk Hasanuddin Hassan that "…*Kelantan State could become the store of illicit drugs, especially pil kuda*…" if the activities of smuggling of illicit drugs are not eradicated immediately (BH Online, 2019). In Kelantan state alone, for the first quarter of 2019, the police had seized 1,347 kg of methamphetamine worth RM 25.4 million, together with 95.7 kg of methamphetamine (syabu) (worth RM 6.5 million); 2.3 kg of heroin (worth RM 262,885); 96.1 kg cannabis (worth RM 192,321) and 6,934 kg of ketum worth RM 63,342 (BH Online, 2019). Figure 2.8 provides another snapshot of the popularity and the market of methamphetamine tablets, specifically in Kelantan State, where RM 4.3 million of various illicit drugs seized in Kota Bharu and Pasir Mas, Kelantan.

Figure 2.8: A snapshot of seized illicit drugs worth RM 4.3 million in Kota Bharu and Pasir Mas (Source: BH Online, 2019).

Nationwide, it was observed that the number of drug users brought into formal contact with the law enforcement authorities (*i.e*. NADA and RMP), including drug users of treatment admissions, has been increasing in recent years as shown in Figure 2.9. As can been seen in 2018, the number of drug users involving the methamphetamine (both crystalline and tablets) had accounted for more than half of the total numbers of all drugs.

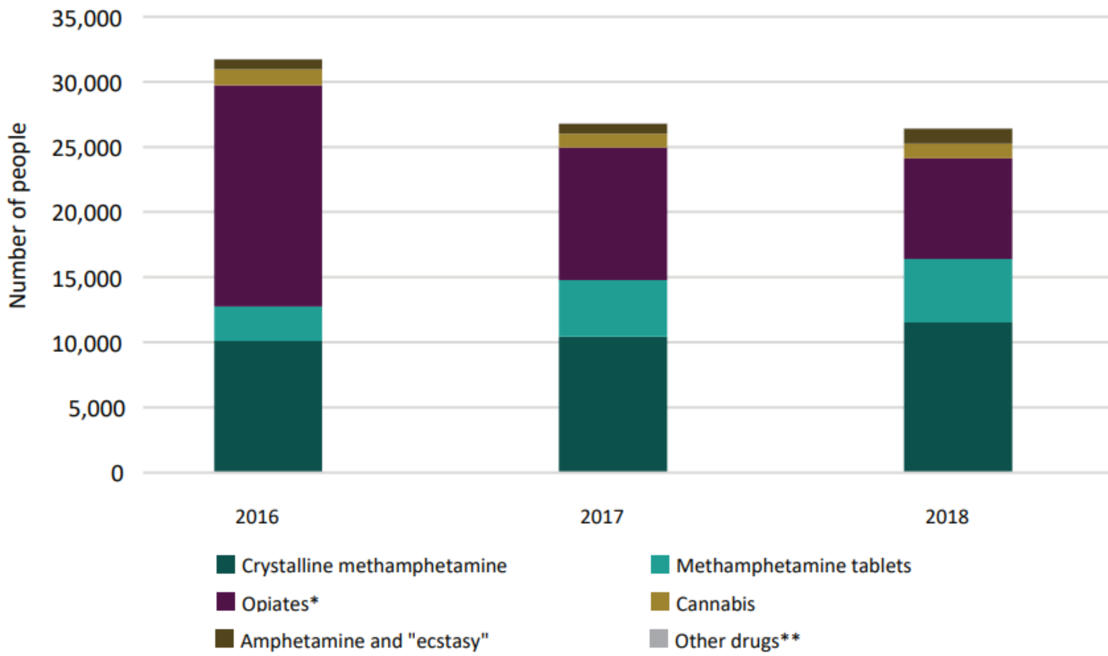


Figure 2.9: Number of people who use drugs brought into formal contact with authorities in Malaysia by drug type, 2016-2018 (Source: UNODC, 2020b)

In terms of supply, Malaysia had experienced a sharp increase in the amount of various forms of illicit methamphetamine seized from 2014 to 2019. Note the huge quantities of crystalline methamphetamine and methamphetamine tablets seized in 2018 and 2019 (Table 2.1) has clearly indicated the degree of methamphetamine problems to the nation, deserving immediate actions from the law enforcement authorities.

Table 2.1: Seizures of methamphetamine drugs in Malaysia from 2014-2019 (Source: UNODC, 2020b).

Methamphetamine	Unit	2014	2015	2016	2017	2018	2019
Crystalline	kg	1212.7	1138.5	718.5	1553.3	6851.8	5831.4
Liquid	Litre/kg	41.8 L	539.2 kg	429 kg	460.0 L	296.9 L	249 L
Tablets	tablets	557337	538176	895499	847334	2512444	1672778

Several cases of large seizure are discussed in the follow sections to delineate the characterises of drug smuggling scale and pattern in Malaysia. In 2018, Malaysia Customs together with Royal Malaysia Police have seized one of the largest cases in the history of Malaysia drug smuggling cases involving 1.2 tonnes of pure methamphetamine in a shipment, declared as “foodstuff” in yellow tea bags bound for a trading company based in a Kuala Lumpur, Figure 2.10.

Figure 2.10: Photo showing packets of 1.2 tonnes of the drug disguised as tea in a shipment from Myanmar seized by Malaysia Customs in 2018.

In 2019, the Kelantan police seized about 200,000 *Yaba* tablets weighing at about 21 kg and 39.21 kg of crystalline methamphetamine worth approximately RM3.7 million, indicating the proximity to Thailand makes the state a route of such drug trafficking. This is an example of many several cases of such encountered in Kelantan (Bernama, 2019). In separate reports, the Police in Thailand had stopped attempts of methamphetamine near Malaysia boarder (Bernama, 2021) and millions of methamphetamine tablets wrapped in waterproof plastic, probably to allow the shipment to withstand the rough sea journey, planned to be shipped to Malaysia (The Star, 2017). All ther reported cases had indicated the routes of smuggling of such illicit drugs from the Mekong regions into Malaysia (UNODC, 2019).

2.4 Methamphetamine Tablet in Malaysia

As described in the previous sections, the methamphetamine tablets, commonly known as "*pil kuda*" in the east coast of the Peninsular of Malaysia, is one of the most common form of methamphetamine drugs widely abused throughout Malaysia. There are several names given to methamphetamine tablets elsewhere, such as *ya-ba*, *ya-ma* or *ya-khayan* which could have been used interchangeably and could have caused confusion to readers.

Historically, methamphetamine was first available as a pharmaceutical product known as Methedrine and called as *ya-khayan* in Thai, meaning diligence tablets which was popular among truck drivers in 1990s. However, due to wide abuse, it had led to government restriction (Farrell *et al.*, 2002). Upon government restriction of legal use by the Thai government, the clandestine manufacturing of methamphetamine began to flood the market with *ya-ma* meaning horse tablet, most likely because of a horse's head logo stamped on the tablet (Farrell *et al.*, 2002). The tablet was subsequently renamed as *ya-ba* meaning crazy tablet due to its adverse health and psychological effects.

Appears in round tablet with a diameter no larger than a pencil eraser and readily fit into a drinking straw, the tablet is most often coloured with red dyes, and sometimes flavoured (National Drug Intelligence Centre, 2003). Typically, a *Yaba* tablet consists of a mixture of approximately 25-35 mg of methamphetamine and 45 to 65 mg of caffeine (Siam Rehab, 2020). The amount of active ingredient and ratio of caffeine to methamphetamine would also inevitably vary. Based on the literature, it may also contain other drugs such as ketamine (McKetin and McLaren, 2004) or heroin (Siam Rehab, 2020). An example of "*pil kuda*" encountered in is shown in Figure 2.11, indicating a packet of "*pil kuda*" typically consisting of 98 red tablets and 2 green tablets.

Figure 2.11: A packet of methamphetamine tablets containing 98 red tablets and 2 green tablets, with each tablet sold at about RM 10 or USD: 0.25 (Photo Source: Manaf, 2018).

2.5 Effects of Methamphetamine Tablet Abuse

The effects of methamphetamine abuse shall be seen from multiple facets. At the individual level, as with other common stimulants, there are various adverse short-term and long-term health effects of abuse of methamphetamine. Of common adverse health effects, the user would experience acute rapid heart rate, elevated blood pressure, hyperthermia, or damage to blood capillary (National Drug Intelligence Centre, 2003). In general, long term methamphetamine use could result in heart lining inflammation, psychosis, and violent behaviours (NIH, 2019; National Drug Intelligence Centre, 2003), and even death.

Specifically, on *yaba* tablet abuse, a case study on a young male of four-year *yaba* tablet abuse exhibited adverse psychological and health effects euphoria, anxiety, increased libido, poor concentration, low self-confidence, irritability, and aggression (Islam *et al.*, 2013). The authors have also discussed that *yaba* abuse shall also be