

CHAPTER 2

REVIEW OF HEROIN: THE EMERGENCE, THE PRODUCTION AND THE ABUSE

2.1 Preliminary

As discussed in Chapter 1, there has been an alarming rising trend in heroin abuse over the years. A large proportion of heroin seizures have been categorized under the possession category in Malaysia. As a result, street doses of heroin are considered in this study in order to derive forensic intelligence from the cases submitted by the local authorities. In this regard, a review of heroin is vital to provide a fundamental insight into this dangerous drug before it is further discussed in forensic drug intelligence.

Is heroin a therapeutic drug or a dangerous substance? The perception varies according to the users. This substance may not be absolutely harmful since its parent compound, morphine is of great medicinal value to help relieve pain in patients. It is detrimental when it is misused for recreational purposes to a degree that this drug brings harmful effects to the community. Although the medical complications associated with the rampant use of heroin are common knowledge to most abusers, a large cohort of them will still continue in its use (Louria, Hensle & Rose, 1967; Loizou & Boddie, 1978). These abusers are characterized as being addicted to and dependent on heroin after a prolonged exposure/abuse.

In view of the current prevalence of heroin abuse in Malaysia, this chapter will review the definition, history, production, properties and pharmacological effects of heroin. This fundamental knowledge essentially provides a guiding principle for the analysis of illicit heroin in the forensic context. This would also serve as the necessary

underpinnings for heroin profiling because unusual clues for forensic intelligence are normally derived from this basic knowledge.

2.2 Drug Classification

Proscribed drugs are known by a variety of names. At present, the common names such as drugs of abuse, controlled substances, illicit drugs, hallucinogens, stimulants, psychotropic substances and narcotics are still being used by many forensic practitioners. To better understand the term 'heroin' in the forensic context, one must first look at the drug classification before the definition of heroin is introduced.

In drug control, drugs are generally grouped into three forms (Roman *et al.*, 2005): 1) a crude form of plants (natural origin) which has a lower potential for abuse, 2) a refined form of synthetic drugs which is more toxic and has a higher abuse potential, and 3) a semi-synthetic form of modified natural components which is more potent than its parent compound. Almost all of the drugs in the illicit drug market usually fall under these three categories.

Crude opium and cannabis that contain morphine and tetrahydrocannabinol (both of which are natural alkaloids) respectively belong to the natural origin. These materials may either be purified, but their natural compounds are not chemically modified. The cultivation of their plants is controlled by legislation. Except for ketum (a plant containing mitragynine) which is listed under the Poisons Act 1952 in Malaysia, none of the cultivation sites of these illegal plants have been reported by the local enforcement unit.

Synthetic drugs such as methamphetamine, MDMA, MDEA, 2C-B and other related compounds are manufactured chemically from their respective parent compounds in clandestine laboratories. The parent compounds are those licit and illicit chemicals procured from legal and illegal sources. They were originally synthesized for

medicinal purposes. Due to the psychoactive effects of these drugs, some unethical chemists synthesize them and sell them in the illicit drug market for huge profits. These substances are now classified as designer drugs as they imitate the effects of other drugs (Clayton, 1994).

Semi-synthetic drugs including heroin, ethylmorphine and benzylmorphine are usually chemically modified by the addition of other functional groups to their original structures. The process involves one or two steps of chemical modification that aim to alter the parent compound which is believed to be less effective in human bodies if administered in its natural form. The modified drug has a better efficacy/efficiency in terms of delivery, responsiveness and activation. With chemical modification, heroin for example is 1.5 – 10 times stronger than morphine (Ghotbi & Tsukatani, 2002; Miller, 2002).

2.3 Definition of Heroin

Different sets of terminologies have been used to describe a specific drug in different contexts. For instance, acetaminophen is also known as paracetamol, an antipyretic, an opioid analgesic and over-the-counter drug. A drug therefore may have a myriad of definitions depending on the education level and context in which the term is used. This again confuses readers when a simple chemical is reported with different names by journalists, news reporters, academics and lawyers in different contexts. Without exception, experts from different fields tend to call heroin by different names.

Heroin is hardly a descriptive name to reveal the chemical property of the substance. Many authors prefer to describe heroin by associating it with other well-known substances. Fraser and Williams (2009) described heroin by associating it with opium which comes from the poppy plant (*Paper somniferum. L*). This term is also perceived by others as ‘a powerful illegal drug made from morphine that some people

take for pleasure...’ (Oxford advanced learner’s dictionary of current English, 2000). From the pharmacological perspective, ‘heroin is an analgesic, or pain relieving drug which belongs to a group of analgesic drugs known as opioids including morphine, codeine...’ (Libby, 2007). In some rare cases, Moraes (2000) described heroin as a brand name for a chemical, diacetylmorphine hydrochloride, a closely related compound of morphine. Similarly, UNODC (2003) broadly defines heroin as ‘a semi-synthetic opiate synthesized from morphine.’

In the United Kingdom (UK), heroin is taken to represent a mixture of products resulting from the acetylation of morphine while in the USA, heroin can sometimes be taken to represent diamorphine and these two terms are often used interchangeably (Cole, 2003).

In the community of heroin addicts, such street names as smack, horse, black tar, ‘H’, junk, brown sugar and others are used to mean heroin. Instead of using the tongue twisting chemical name, these street names are used to communicate between the manufacturer and the abuser to make deals. In the Chinese community, a common street term called ‘bai fen’ (meaning ‘white powder’) is also used. The addicts are not specifically describing the white color and fine texture of the drug. This term was probably coined by the old generation when they first encountered heroin in a white powder form. Hence, this term is passed down to today’s generation but this street name does generally refer to heroin in any color and in any form.

Based on the above contentions, the name ‘heroin’ is widely accepted by the addicts and forensic experts to refer to any entity such as powder or pill that contains a modified morphine-based product called ‘diacetylmorphine’. Also, this term is merely one of the common names used by the addicts. However, most judicial systems prefer to explicitly use ‘diamorphine’ or ‘diacetylmorphine’ to accurately describe the presence of such substance in a drug sample. It is because the term ‘heroin’ has been overused to

represent the whole drug entity including other parts of substances within the entity not listed as dangerous drugs.

In this study, 'illicit heroin', 'heroin sample' or 'street heroin' is used to mean the gross substance seized from the street which may or may not contain 'diacetylmorphine' or 'heroin', the active ingredient in the drug entity. When 'illicit heroin' or 'heroin sample' is cited, other substances such as adulterants/cutting agents and its associated alkaloids should be considered. When 'diacetylmorphine' or 'heroin' is used, only such specific compound is referred.

2.4 Heroin: From Past to Present

Diacetylmorphine (or heroin) is a derivative of morphine which is extracted from the poppy plant of the *Papaver* genus. From the plant, opium containing mainly morphine and other opium-based alkaloids is extracted in coagulated latex. The opium will be prepared and processed to form heroin. To understand heroin, it is more practical to first understand opium and its related compounds. To this end, the historical emergence of opium is briefly described.

Opium is probably the oldest type of drug for it has the earliest historical records compared to any other drugs. The first appearance of opium is vague. Schiff (2002) traced the earliest record of opium use by the Sumerians back to 3000 B.C. whereas Campbell and Langford (1995) found it in 5000 B.C. Adler *et al.* (1998) contended that the historical use of opium was associated with religious rituals. Despite its reason for ancient use, the opium introduced by Arab traders into China during the sixth century was mainly for medicinal purposes. During that period, there were no reports of opium abuse among the Chinese until the 1700s (Cherry, Dillon & Rugh, 2002). Due to the continuous supply of opium, the use of opium became widespread. Pipes were used to smoke tobacco with opium added to it. Gradually, the addiction to this drug also

became widespread. At that time, the British who were the chief of the opium supply in India made a fortune out of these natural commodities by supplying the drug to the addicts.

In Europe and the USA, opium was used in a liquid form and this solution was better known as Laudanum or 'black drop'. This was the drug of choice for women who frequented bars or saloons. Besides, opium dependency or addiction ensued when opium-based remedies were often employed to suppress cough, to cure diarrhea and to quiet the occasionally delinquent child.

Opium trade served as an impetus for the German scientist to discover various medical uses of opium derivatives. Morphine (meaning 'Greek god of dreams') was successfully isolated from opium in 1803 and has been commercialized by E. Merck and Company since 1827. Other discoveries of opium-based alkaloids were codeine in 1832 and papaverine in 1848. Morphine was used for relieving pain of those wounded in battles. But its frequent use had led to serious morphine addiction among veterans during the American Civil War.

A large dye firm called Bayer had a very advanced laboratory for pharmaceutical research. A reputable chemist called Heinrich Dresser working for this firm was particularly interested in the acetylation process. Dresser theorized that this process could reduce the side effects of many medications and also increase their potency (Carnwath & Smith, 2002). Subsequently, in the year 1874 the history of opiate addiction reached a turning point. The year marked the discovery of heroin by a British chemist, C. R. Alder Wright, who found that boiling morphine with acetic anhydride could produce diacetylmorphine (Fernandez, 1998). This chemical was commercialized by Bayer with a brand name 'Heroin'. This commercial product was initially used to suppress cough in patients with tuberculosis. Besides, it had also been widely used since 1899 as an alternative in treating morphine addiction before it was recognized to be a

narcotic and addictive in nature (Courtwright, 1982). Finally, heroin was controlled in the USA through the Harrison Narcotic Act of 1914.

By the late eighteenth century, addiction to opium reached serious level and was rampant in China. This phenomenon had compelled the local government to outlaw opium use as a serious crime and prohibit the entry of opium from India. This action had provoked anger from the British who then started the Opium War of 1840-42 and many were sacrificed for the sake of opium. After the war, the western countries had begun to cultivate opium for local consumption. Finally, a series of international conferences calling for laws against opium were organized to combat this menace. The resolutions however met with failure as the cultivation and the use of opium had not been eliminated.

According to Hogshire (2005, May 1), the first period of large scale heroin smuggling into the USA since its prohibition occurred during the years 1967 through 1971. Opium from Turkey was processed into heroin in France and then smuggled into New York. During the mid-1970s, heroin produced in Mexico known as the 'Mexican brown' appeared. This drug was stronger and cheaper than the Turkish white heroin. On the other hand, the 'Golden Triangle' (or Southeast Asia), the 'Golden Crescent' (or Southwest Asia) and Latin America have also become well-known for the cultivation of illicit opium poppies. These regions form a monolithic foundation to sustain the supply of heroin as they have the uninterrupted opium cultivation sites to produce large amounts of opium latex. By the end of 1982, Southwest Asian heroin achieved a monopoly of the illicit market in Eastern and Central Canada due to a poor harvest in Southeast Asia between 1978 and 1980, while Southeast Asian heroin continued to dominate the west coast market (Stamler, Fahlman & Keele, 1983). The World Drug Report (UNODC, 2009a) reveals that Myanmar had emerged as the largest opium cultivation site from 1994 to 2002 while showing a descending growth rate from 2003

to 2008. However, the recent report (UNODC, 2011) again highlights the fact that Myanmar has remained as one of the major suppliers of opium in the Asian region. Additionally, Afghanistan has become the major cultivation site for the world's opium since 2003. Other cultivation countries include Pakistan, Laos, Viet Nam, Thailand, Columbia and Mexico. Of late, the rise of heroin is on par with that of opium. For example, UNODC (2009a) records that in 2007, 28% and 15% of the world heroin seizures involved heroin originating from Iran and Pakistan, respectively.

Probably, the use of opium was mainly brought into Malaysia by the merchants coming from China during the trade along the Straits of Malacca. Opium use in Malaysia is now less prevalent but heroin which is believed to be imported from the 'Golden Triangle' remains the major drug of use over the past decades. According to Figure 2.1, the major proportion (43.8%) of the total seizures in 2009 is dominated by heroin. Most of the seizures belonging to the possession category under the DDA 1952 were frequently found in personal possession, in the premises and in the vehicles. They were and are still usually packed in small plastic packets and straw tubes for quick consumption. In other instances, the smugglers used posters, drawings, towels and detergent containers to conceal the drugs, to evade detection by the customs officer. Other traffickers employed the dangerous method of swallowing the packaged heroin samples to pass through the customs check-point. Heroin abuse and heroin trafficking have been incessant and these phenomena are still being observed in the current context.

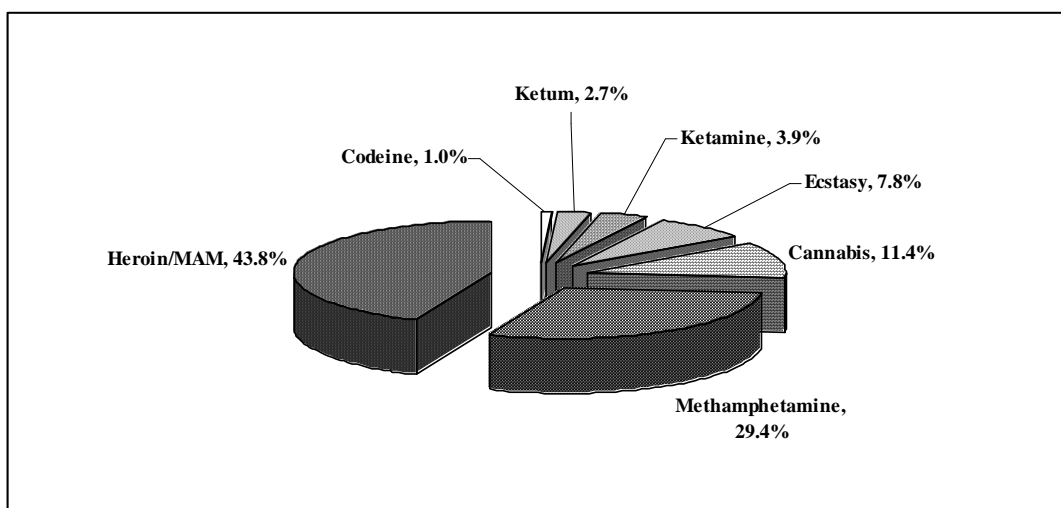


Figure 2.1: Frequency of drugs of abuse submitted for analysis in Malaysia in 2009

2.5 Manufacture of Illicit Heroin

2.5.1 Introduction

When the coagulated latex is further processed, heroin will be the end product of opium. There are approximately 110 species of *Papaver* identified by the botanists, but only two namely, *P. somniferum* and *P. setigerum* are able to produce morphine in substantial amounts (Fulton, 1944; Farnilo, Rhodes, Hart & Taylor, 1953). In the past, the legal definition of raw opium in Malaysia (Chan, Rahim, Ng & Raof, 2010) assumed these species as the source of opium. Finally, scientific findings suggest that only morphine extracted from the latex of *P. somniferum. L.* is often used by the clandestine laboratory to produce heroin. In the final product of heroin, other opium-based alkaloids such as codeine, papaverine and thebaine are also present as they are usually co-extracted and processed along with the morphine extracted from opium.

To yield a large amount of heroin, the clandestine production relies heavily on the quality and quantity of opium poppies available for processing. The production of heroin comprises several stages, starting from opium cultivation, isolation of morphine, conversion of morphine to different forms of heroin, the cutting process, to finally the packaging process. With this multistage process, it has the potential of allowing the

formation and introduction of various impurities in the form of co-extracts, by-products and foreign traces into the final product. As can be seen in Figure 2.2, monoacetylmorphine (MAM) is one of the by-products from the incomplete reaction between the acetylating reagent and morphine. This frequently happens in the illicit manufacturing because the process is conducted by unskilled chemists without proper quality control. In fact, nearly all clandestine laboratories are not stringent with their laboratory practice as they attempt to maximize the productivity and minimize the production cost. Therefore, all illicit products contain high amounts of impurities.

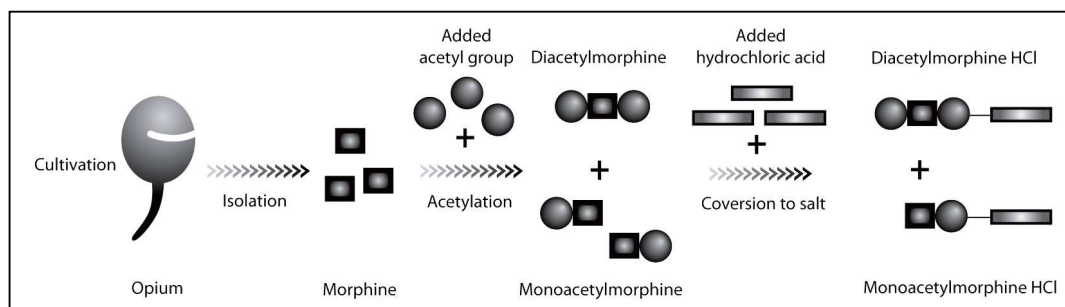


Figure 2.2: General scheme of heroin production

Adding to the above-mentioned impurities, illicit heroin is a very ‘dirty’ drug as it is vulnerable to contamination during packaging and transportation. The low quality control and unskilled workers further compound the contamination problem when improper techniques and unwashed utensils are used to process the drug. Very frequently, the working environment (e.g. a living room) lacks the basic laboratory equipment and laboratory safety. In this type of factory based on residential premises, a variety of trace compounds not intended by the manufacturer will be introduced into the street heroin. Hence, every batch of heroin can be expected to contain a large pool of organic and inorganic impurities acquired from the multistage process from cultivation through processing, cutting and finally to packaging.

2.5.2 Cultivation

Environmental factors determine the quantities of alkaloids present in the poppy plant. Plants grown in west and central Anatolia, Turkey for example have been recognized to have high alkaloid contents due to its favorable climate and ecological conditions (Çopur, Göger, Orbey & Şener, 2005). An exhaustive list of reasons for selecting suitable fields with ideal conditions for opium cultivation was detailed by Parrish (1849). Commonly, the *P. somniferum* species prefers a cool or moderate climate and loose soiled area preferably at pH 7 to grow. The growing cycle of the opium poppy takes about 4 – 7 months. Ideally, a farmer cultivates and harvests two crops in a 12-month period. The plant germinates quickly in a warm field with sufficient moisture. In the ‘Golden Triangle’, the opium poppy grows best at altitudes of 1,000 m or more above sea level along the mountain slopes and ridgelines (Lee, 2006).

The opium poppy usually takes about 2 months to grow 1 – 2 feet in height with a long stem but in some occurrences they may show multiple stems. When the stem reaches 2 – 5 feet in height, its end terminates into a flower bud that will eventually deploy a white to purplish-red flower depending on its variety. For instance, white flowers and white seeds belong to the variety of *album*, purple flowers and slate-grey seeds belong to the *nigrum* variety and purple flowers and purplish black seeds to the *grabrum* variety. Opium poppies generally flower after about 90 days of growth and continue to flower for 2 – 3 weeks before they fully expose the pods. The pod portions resembling capsules continue to grow in size for about 14 – 20 days to allow the opium alkaloid contained within it to accrue. The farmer harvests the opium latex from the pods by making a 1 mm deep incision vertically with a blade a few weeks after the petals have fallen from the flower (Figure 2.3). Subsequently, the whitish latex exuding from the seed heads dries and oxidizes in the sun and the dried latex masses are

collected the following day. The empty pods are then allowed to dry since the seeds can be recovered for next cultivation.



Figure 2.3: Opium poppy
(Source: Europe Against Drugs, EURAD)

According to Cole (2003), a pod may produce 10 – 100 mg of opium. The latex is usually transferred to thin plastic bags and sold by weight. During the early to mid 1990s, the farmers shortchanged the buyers by diluting the latex to increase its weight (Paoli, Greenfield & Reuter, 2009). In a fresh state, the latex is sticky, tar-like and dark brown, and becomes brittle and hard as it ages and becomes dried. Opium abusers use the fresh opium by smoking and chewing. The latex contains approximately more than thirty alkaloids with the remainder of the latex comprising sugars, proteins, lipids, gums and water (UNODC, 1998; Cole, 2003). At this stage, the natural latex is also known as raw opium. According to the legal definition as stipulated by the DDA 1952, raw opium specifically means the coagulated juice obtained from any plant from which morphine may be produced, whatever its content of morphine and in whatever form the coagulated juice is, but does not include medical opium (LRB, 2004). In the opium, approximately 4 – 21wt% morphine, 0.7 – 3.0 wt% codeine, 0.2 – 1.0 wt% thebaine, 0.5 – 1.3 wt% papaverine and 2 – 8 wt% noscapine (also called narcotine) are present

although narceine at concentration below the five alkaloids was also frequently reported (UNODC, 1998; UNODC, 2003). The first three alkaloids are also known as phenanthrene alkaloids and the latter two as isoquinoline alkaloids. The chemical structures of these five natural alkaloids are presented in Section 2.4: Physical and Chemical Properties of Opium Alkaloids.

2.5.3 Isolation of Morphine

The opium latex contains varying amounts of alkaloids, but only morphine is targeted by the heroin manufacturer. As the raw opium is water soluble, isolation of morphine from the bulk liquid is done by mixing the dried latex with hot water. Most of the water insoluble substances such as plant materials will float and can be removed or filtered from the solution. If the solution is evaporated to produce a thick brown paste, the paste is called cooked opium or prepared opium. Prepared opium is usually smoked with the aid of a long pipe. After consumption, the residue in the pipe is called dross opium in which morphine is still present. However, if the solution is not evaporated and calcium oxide (anhydrous lime), calcium hydroxide or calcium carbonate is added along with a large volume of boiling hot water into the solution, this step will extract morphine from the opium. In this process, the calcium containing compounds added will convert the water-insoluble morphine into water-soluble calcium morphinate. When the solution is cooled and other unwanted alkaloids will precipitate, while the morphine and some codeine (which is water-soluble) remain in the solution. In the experiment conducted by Zerel, Ahrens and Gerz (2005), they obtained a brownish foam residue and an oily film on the surface of the morphine solution when the hot water/solution was left to stand overnight.

The morphine solution can then be separated from the water-insoluble opium components through filtration using cloth rice sacks which can then be squeezed in a

press to remove most of the solution from the wet sacks. Subsequently, the solution is re-heated. Morphine base precipitates out upon the addition of ammonium chloride (and sometimes ethanol and diethyl ether) into the solution for pH adjustment to the range between 8 and 9. The resulting crude morphine (also known as Heroin No. 1) is filtered off the bulk solution and is dried in the sun. At this point, the resulting coffee color morphine base will be further processed to produce heroin base.

If purification of morphine is desired, the crude morphine is converted to morphine hydrochloride by dissolution in hot hydrochloric acid (or sulfuric acid or tartaric acid) to form a morphine solution prior to the addition of activated charcoal, followed by reheating, filtering and finally cooling. The morphine salt is recovered by filtration. This final product obtained in an off-white powder can be compressed into bricks and blocks for transportation. Alternatively, the free base of morphine in a granular solid can be obtained by remixing ammonium hydroxide with the morphine salt solution (Narayanaswani, 1985). Generally, the isolation step is relatively feasible at any home-based laboratory in view of the fact that the reagents and apparatus required for this procedure are cheap and commercially available.

The extraction of morphine and the production of morphine base or its salt are not limited to one exclusive method. Five established chemical methods aimed at producing morphine base or its salt have been discussed by Karch (2006). The methods are summarized as follows:

1. **Thiboumery and Mohr Process (TMP)** utilizing hot water, calcium hydroxide, ammonium chloride and morphine hydrochloride coupled with filtration, heating and evaporation.

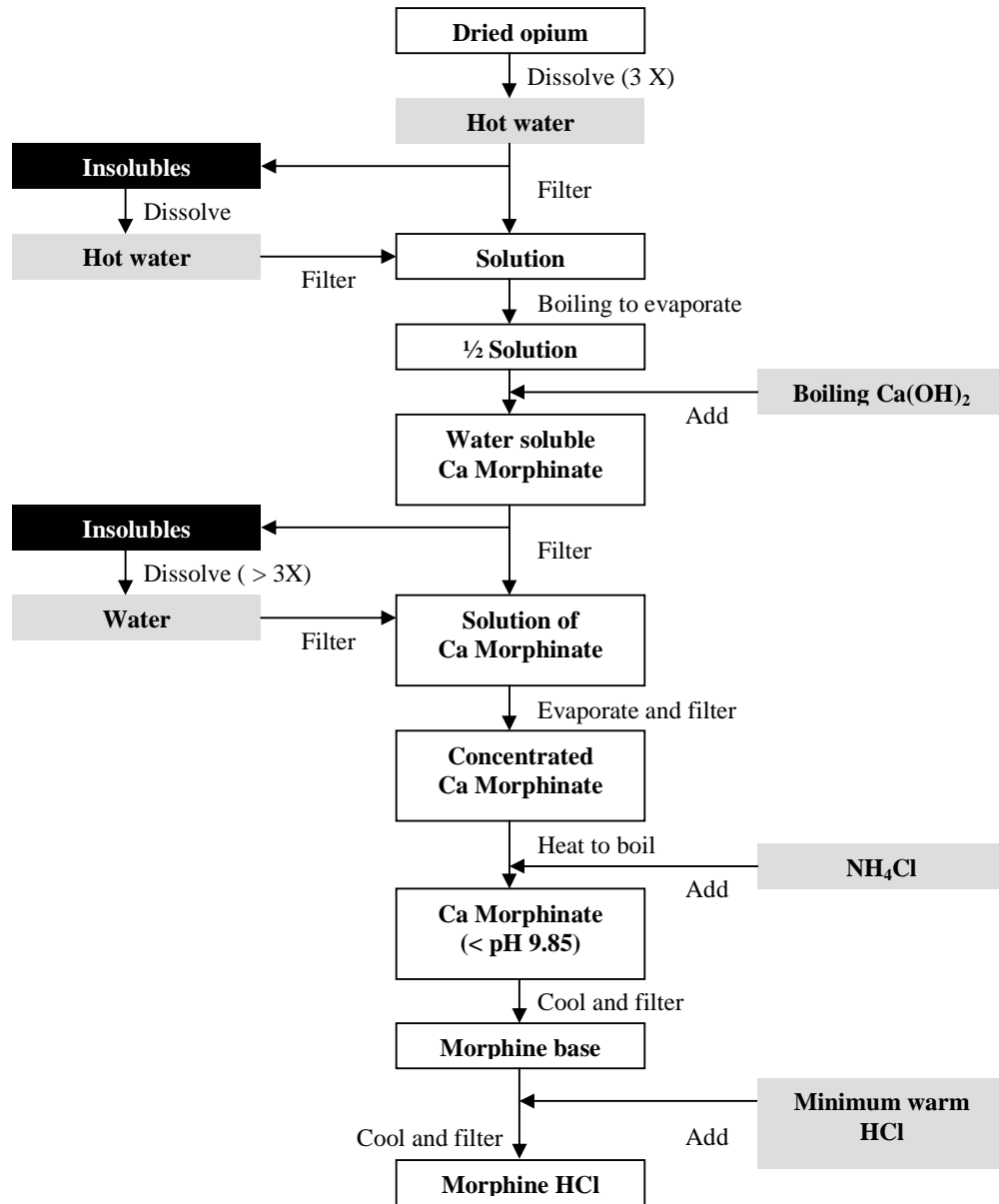


Figure 2.4: Flow chart of Thiboumery and Mohr Process

2. **Robertson and Gregory Process (RCP)** utilizing cold water, calcium chloride and ammonia coupled with filtration, boiling and evaporation.

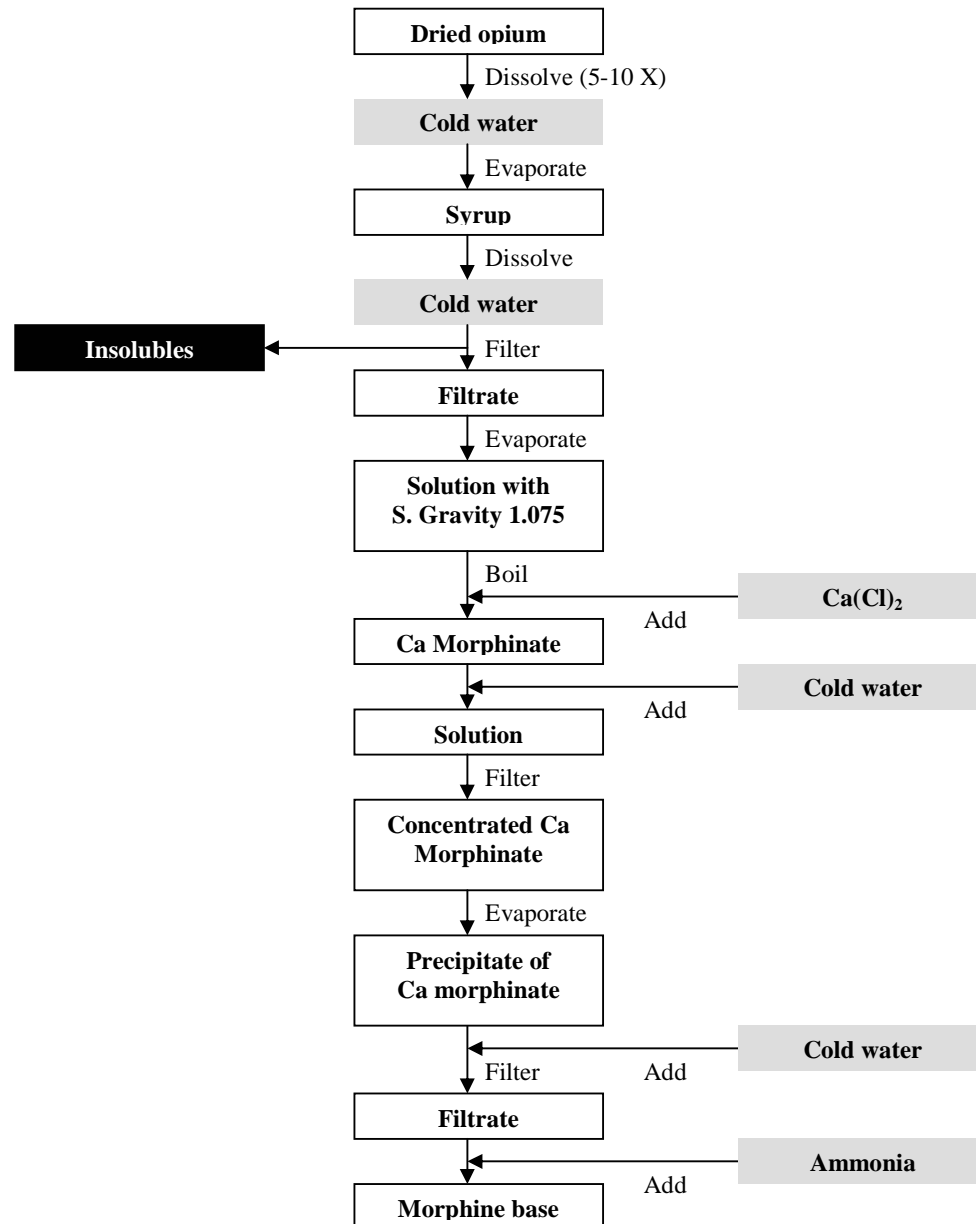


Figure 2.5: Flow chart of Robertson and Gregory Process

TMP and RCP are aimed at producing morphine base of relatively lower purity. The following three methods are best suited for the purification of morphine base with better efficiency.

3. **Barbier Purification** using hot water, tartaric acid, ammonia, activated carbon black, sodium bisulfite, sodium acetate, ammonium oxalate, 30% ethanolic hydrochloride and ethanol together with filtration.

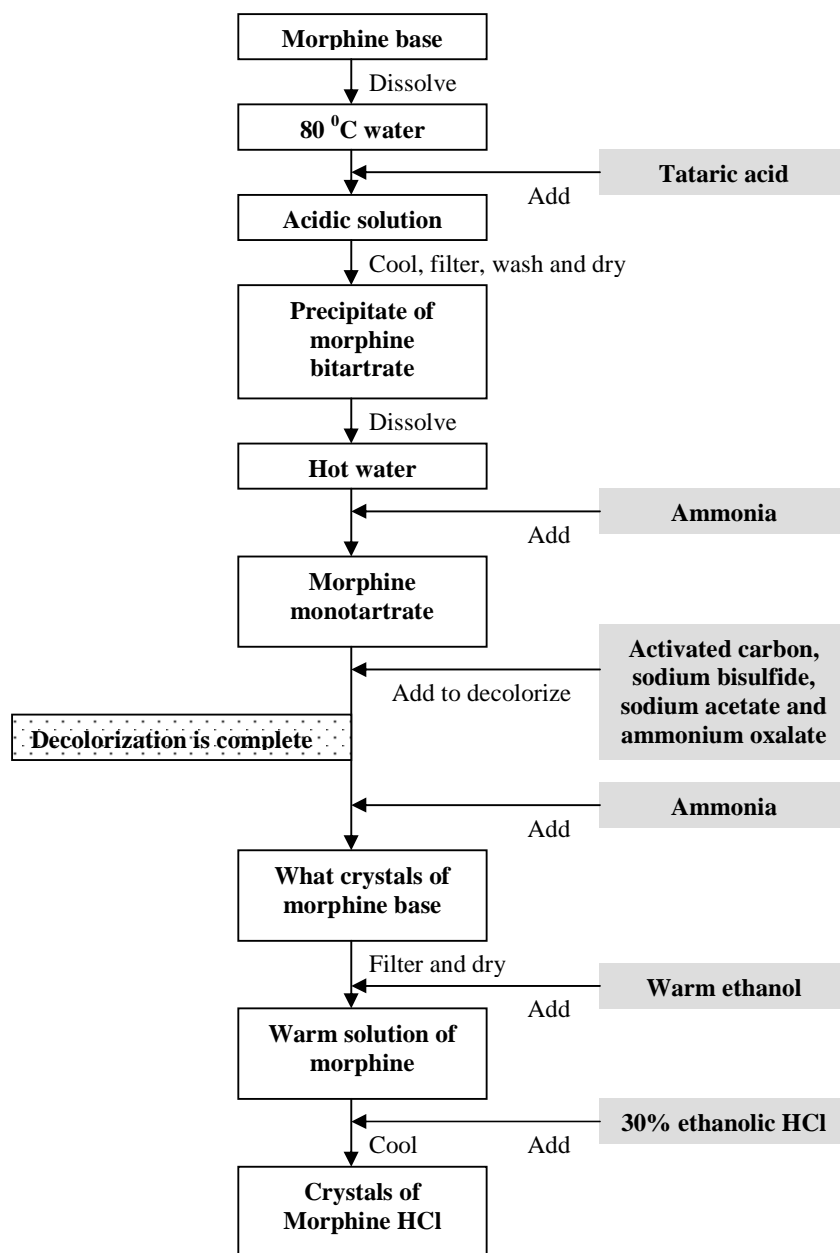


Figure 2.6: Flow chart of Barbier Purification

4. **Schwyzzer Purification** washes the acetone-insoluble morphine base produced from TMB or RGP with acetone, after which it is re-crystallized from hot ethyl alcohol.
5. **Heumann Purification** washes the morphine base produced from TMB or RGP with trichloroethylene, followed by a cold 40% wash and an aqueous acetone wash.

The above-mentioned methods are commonly employed by both legal and illegal manufacturers in the production of morphine. TMP or 'lime method' was known to be largely adopted by the clandestine laboratories (UNODC, 2003). How closely the above processes are followed depends upon the intentions of the manufacturers producing the morphine. If the clandestine manufacturers are selling morphine to the end users, the morphine will be relatively pure and of better quality. Also, extra care is given during the purification step to assure the purity of the product. Conversely, if the clandestine laboratory proceeds to acetylation for the production of heroin as the end product, the resulting morphine will be quite impure. Undoubtedly, the poor quality of the morphine and/or its salt is also attributed to the low competence of the chemist purifying the product and the poor quality assurance in the clandestine laboratory.

Due to the advancement in chemistry, morphine can now be synthesized rather than extracted. Most synthetic products have replaced the natural starting compounds for production. In relation to this, Gates and Tschudi (1952) first reported their seminal work of Gates' synthesis of morphine in an international journal. The availability of synthetic morphine in turn provides another gateway to the synthesis of heroin. Subsequently, various other such methods as Rice's Synthesis, Evan's Synthesis, Overman's Synthesis, White's Synthesis and Parker's synthesis emerged spanning across 1980 – 2006. Among these methods, Rice's Synthesis is able to give the highest

yield of morphine up to 12% (Wong, 2008). When synthetic morphine is used as a precursor for heroin production, the resulting synthetic heroin may lack the characteristics of the processed heroin derived from the natural morphine. For instance, the absence of other opium-based alkaloids is particularly notable in the product processed from the synthetic morphine.

2.5.4 Conversion of Morphine to Heroin Base

Acetylation is a chemical process that converts morphine to heroin base with the aid of a colorless but highly combustible acetic anhydride liquid (Figure 2.7). The liquid is also a controlled substance and its possession is illegal because it is known to have a function in converting morphine to heroin (Moraes, 2000). Other acetylating agents such as glacial acetic acid, acetyl chloride and ethylidene diacetate have also been employed. In the case of ethylidene diacetate, it is added to sulfuric acid or zinc halide, and the mixture can produce acetic anhydride upon heating. Sometimes, a mixture of acetic anhydride and acetyl chloride is also used to enhance the acetylating effect.

For acetylation, the relatively impure morphine base or the purified morphine hydrochloride is placed in an enamel pot, to which acetic anhydride is added to react with morphine, producing heroin acetate. The pot is clamped tight and heated at 85°C for 2 – 5 hours. Boiling of the solution or excess heating is avoided in this step. The solution is agitated to dissolve all the morphine by tilting or rotating the pot to allow the acid and morphine to react in the mixture. When this process is complete, the pot is cooled and opened. In the mixture, an impure form of diacetylmorphine (or heroin) is formed. Water is then added to the mixture with stirring. In this process, a small amount of chloroform may be added together with the water and after 20 min a red greasy liquid will be formed at the bottom which can dissolve most of the impurities. The aqueous layer is mixed with activated charcoal to absorb the impurities. This

solution is then filtered to remove solid impurities, leaving behind a light yellow solution. This process is repeated until the solution becomes colorless since activated charcoal and the previously added chloroform help to decolorize the solution. Now the solution containing relatively high-grade heroin is transferred to another container. Sodium carbonate in hot water is added to the colorless heroin solution until effervescence stops. This step will precipitate out the heroin base as a white solid. The product is then filtered and dried by heating in a steam bath. It is also practical to re-dissolve any colored heroin base in dilute hydrochloric acid or citric acid (Narayanaswani, 1985) and be charcoal-treated, re-precipitated and finally dried to obtain a brighter heroin base. The heroin base produced at this stage is also called Heroin No. 2. Most illicit manufacturers however ignore the color and this heroin would be packed and sold without further reprocessing. Typically, one kilogram of morphine can produce a slight excess of heroin base.

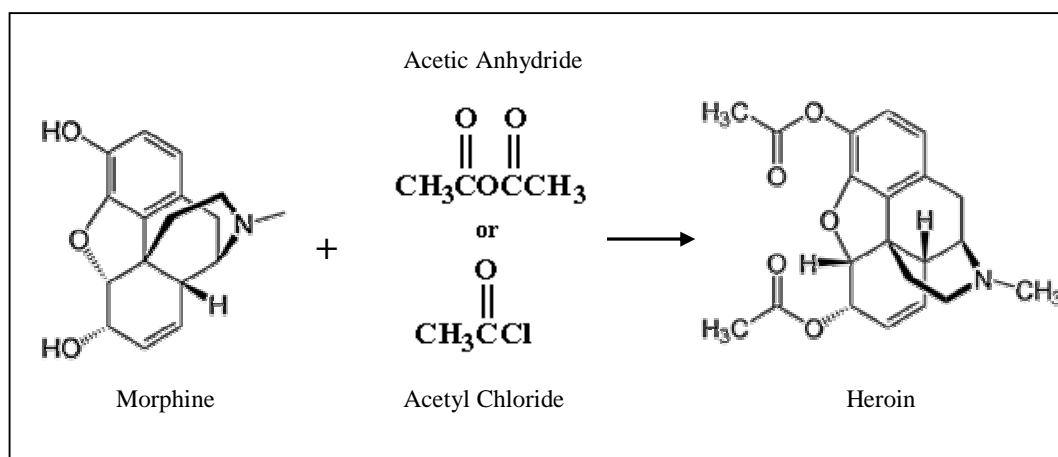


Figure 2.7: Conversion of morphine to heroin base

2.5.5 Conversion of Heroin Base to Heroin Hydrochloride

Heroin base is less stable than its salt (UNODC, 2005). To enhance the stability of heroin, the free base is usually converted into a hydrochloride salt. The heroin base is

dissolved in ethanol to which concentrated hydrochloric acid is added. Other adulterants such as caffeine may also be added at this stage. Once all of the base is converted to heroin hydrochloride, ethanol and diethyl ether are added. After a few minutes, the crystals of heroin hydrochloride form and diethyl ether is further added and the mixture is covered and allowed to stand. Finally, the mixture is filtered and the solids are collected on a filter paper and dried on a tray. The resulting solid heroin hydrochloride will be in the form of coarse white lumps. This solid may be crushed into smaller particles or powder for packing and shipping. A rather simpler and economic process experimented by Zerel *et al.* (2005) requires hydrochloric acid and a small amount of acetone to form the white heroin salt.

The final product, typically consisting of 98% heroin hydrochloride is called Heroin No. 4, which is also an injectable form of heroin and it is sometimes called 'China White' or 'Thai Heroin'. It fetches high prices in the illicit drug market because it contains a high level of heroin in the drug. Heroin No. 3 on the other hand contains 25 – 45% of heroin hydrochloride. This is an inhalable form of heroin which is often adulterated with other substances such as caffeine and ascorbic acid.

2.5.6 Cutting Process

In the processing of opium to heroin, many impurities such as acetylated products, degradation products and contaminants may invariably be introduced into the final drug product. When heroin is distributed in the black market, it will become more impure and diluted as the drug is cut (diluted/adulterated) in the distribution chain. Cutting refers to a process of diluting the heroin with other substances called adulterants or cutting agents with the intention to lower the drug purity and increase its bulk. Specifically, adulterants also refer to substances intentionally added to serve specific pharmacological purposes. However, cutting agents are merely the substances added to

increase the bulk mass of the drug. These substances serve no function when administered with heroin. With this cutting procedure, more packets of heroin can be obtained if a small amount of the drug is cut or adulterated with other substances.

During the cutting process, a small amount of heroin is mixed with large quantities of substances such as paracetamol, caffeine, chloroquine and phenolphthalein. These substances are cheap and can be easily obtained commercially. Other reasons for their use in cutting have been discussed in UNODC (2009, June 22). Some of the known reasons are also presented in Table 2.1. However, these reasons are general and its intended use is not thoroughly understood. For example, Eskes and Brown (1975) could not rationalize the use of caffeine and strychnine found in the heroin-caffeine-strychnine mixture which was first encountered in Amsterdam.

Table 2.1: Specific purposes or reasons of adulterants or cutting agents in heroin

Adulterant/ Cutting agent	Specific purpose/reason
Caffeine	To cause heroin to vaporize at low temperature
Quinine hydrochloride	To treat malarial infection transmitted from needle sharing To enhance the taste of heroin
Strychnine hydrochloride	To enhance the taste of heroin
Acids	To convert heroin base to a salt form
Acetaminophen	Easy to purchase and relatively cheap
Sugar	Easy to purchase and relatively cheap

Acids including citric acid, ascorbic acid and vinegar added to the heroin base in particular may change the base to salt when the drug is heated before injecting. Other narcotic drugs could also be chosen as one of the cutting agents in cutting the drug. For example, noscapine (an opium-based alkaloid) was once suspected to be one of the

adulterants used in illicit heroin samples (Klemenc, 2000). The cutting process may take place at any point along the distribution chain. By the time the illicit heroin reaches the end user, it is often about 40% pure and little is known about what makes up the other 60% of any given batch of heroin (LeVert, 2006). Ironically, the constituents of the non-diamorphine portion, whether known or unknown, may be more injurious to the human body than the heroin *per se*.

2.5.7 Street Products: Heroin Powder or Pills

Illicit heroin is available in two forms, namely granular powders or compressed pills/tablets. Street heroin confiscated from the distributors and drug users are present in granular powders which the users have to grind the entire sample into a fine powder before use. In most cases, the granular heroin is packed as coarse particles and rock-like granules as they would help reduce the surface area, thus preventing the absorption of moisture. It is because water molecules can hydrolyze heroin to MAM (UNODC, 2005), so the compressed mass can preserve the heroin without exposing too much of the ingredient to the atmospheric moisture. Besides, illicit heroin is commonly sold in different colors. Conventionally, colored powders in brown, pink, yellow, green and gray with a hard texture are considered low grade heroin. Higher purity heroin normally appears as a fine whitish powder.

Heroin pills do exist and its emergence was detailed by UNODC (1953, January 1). These pills are not consumed orally like all other pharmaceutical tablets. The heroin pills have to be crushed into a powder before it is heated for consumption. The classical manufacture of heroin pills involved rolling the heroin mixtures and cutting them on a machine. These pills are then manually rounded and dried in a desiccating cabinet to form the ultimate spherical shape. The pill production process is far simpler than the modern production of tablets. The latter may require binders, disintegrators, lubricants

and drying agents as well as a commercial tablet press bearing some logo to form fine shaped tablets. Heroin pills/tablets are not widely consumed or commonly seized because they require powdering before consumption. Thus, recent heroin samples are preferably kept in a granular powder form. If the tablets containing heroin exist, heroin may only be one of the adulterants rather than the main constituent in the sample. Such occurrence was observed in the ecstasy pills and oxycontin imitation tablets reported by Hung *et al.* (2005) and U.S Drug Enforcement Administration (2009).

Production of tablets in fixed sizes offers conveniences to the manufacturer. For example, a correct dosage is easily determined if the buyer wishes to know how much to take. It also provides a means of measuring the amount in terms of how many units of such drug are produced in a single production. Conversely, when the end product of illicit heroin is left in the form of irregular particles or masses of substance, unfixed and highly variable weights can be observed in a single batch of heroin. Another reason for leaving the final product as such without further processing into tablets could be cost and time savings in production.

In forensic investigation, granular heroin lacks the information that tablets could offer. This information refers to a range of physical complexities associated with the tablet for detailed analysis. In this regard, Humphreys (1984) argued that illicit tablets allow tentative identification of active constituents. For example, blue tablets of approximately 8 mm in diameter usually contain stimulants such as amphetamine, pemoline or diethylpropion. Despite the lack of tablet-related characteristics, the receptacles used to pack the illicit heroin could also be a useful alternative to obtain this information in many ways. Hence the details on the package should not be overlooked since all powdered drugs are packed into packages and containers. At the very least, two important aspects can be studied from a packaged heroin sample:

1. A wide range of characteristics can be obtained from the receptacle and this information could be used to link the drug to the previous person in the distribution chain. In this case, it is assumed that the final packing is decided by this person.
2. Active ingredients, major compounds and impurities determined from the heroin sample could provide information on the chemical composition of the drug. An exhaustive search of these compounds will help construct the stories from 'seed to seek' whereby 'seed' and 'seek' are respectively the temporal points of cultivation and investigation. This phrase is used to mean profiling the chemical constituents collectively inherited from the activities such as cultivation, manufacturing, distribution and abuse.

2.5.8 The Entry of Impurities

The final heroin sample submitted for laboratory analysis is usually exposed to many levels of contamination. Figure 2.8 depicts how traces of impurities and contaminants enter the heroin sample at various stages (refer to Section 3.3.2 'Profiling of heroin' also). Generally, illicit heroin can be mixed with any impurities and contaminants at any stage. It is due to the fact that quality control is absent in the illegal refineries. Very often, adulterants and cutting agents are added at the manufacturing level as well as a multiple points in the distribution chain. Sometimes, when the illicit heroin reaches the retail level, cutting agents/adulterants and ingredients for tableting may again be added prior to street sale. It is at this stage that a number of known and unknown compounds have entered the final street product, complicating the drug history. Hence, identification of the impurities in the drug sample and the conclusion based on the identified compounds can be a formidable task because interpretation of

the data requires in-depth knowledge about the drug history. As each heroin entity will ‘encounter’ different impurities along the distribution chain, it can be assumed that only those samples passing through a similar distribution route will show similar chemical profiles. This also forms a hypothetical basis for drug profiling to track down the distribution route.

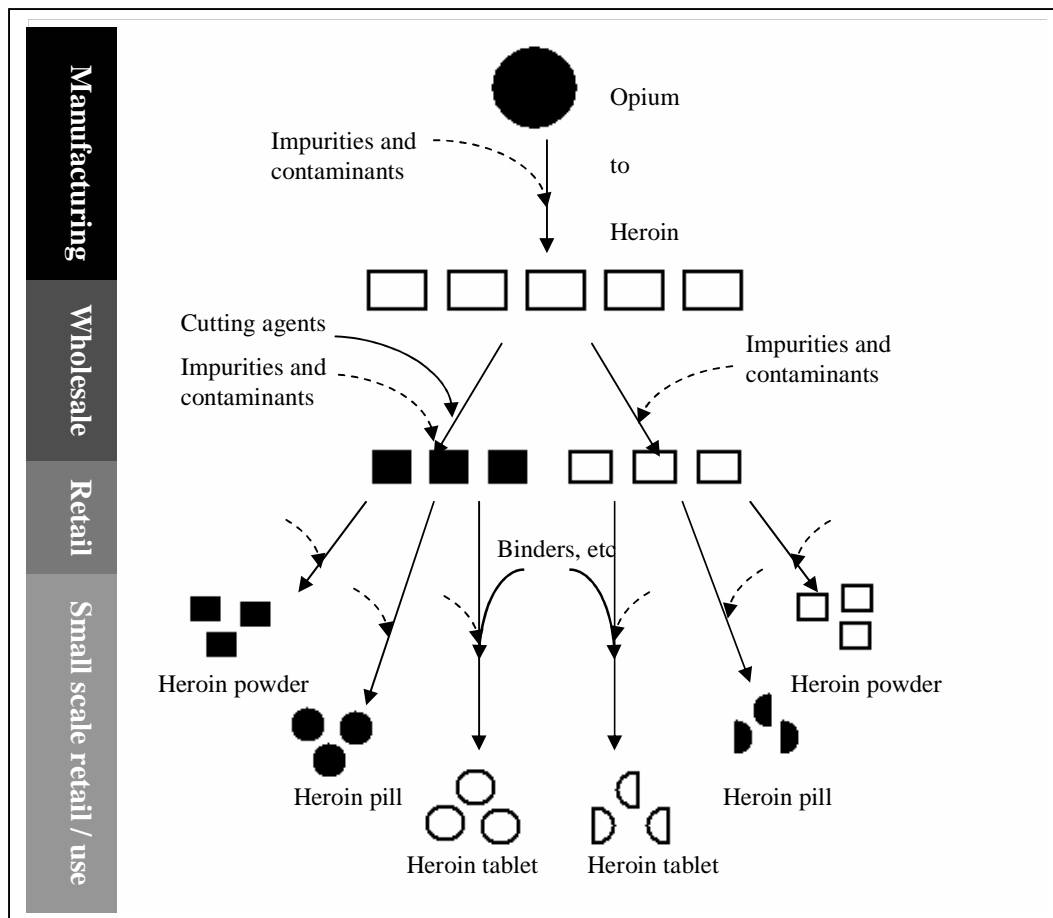


Figure 2.8: General routes of production of street heroin

2.6 Physical and Chemical Properties of Opium-based Alkaloids

A heroin sample may contain a large number of opium-based alkaloids, whereby at least five major alkaloids are commonly present in quantifiable amounts in most street samples. During the acetylation process, some of these natural alkaloids are inevitably acetylated. For example, codeine and morphine are respectively modified to

acetylcodeine and MAM in the final heroin product. Other acetylated products such as acetylthebaol and diacetylnorcodeine are also frequently reported but they are usually present in trace quantities. Appendixes 1 – 8 detail the physical and chemical properties of eight selected alkaloids frequently detected in the Asian heroin samples. They are heroin, codeine, morphine, thebaine, papaverine, noscapine, acetylcodeine and 6-MAM. In the case of MAM, it can be present in two isomeric forms, 3-MAM and 6-MAM with the latter being the most common degradation product of heroin.

2.7 Pharmacology of Heroin

Heroin in tablet form enters the human body through oral administration. In the case of Heroin No. 4, intravenous route of administration through injection provides the fastest and greatest effects in the body within several seconds while the intramuscular means delay the effects by a few minutes. The slowest means of snorting exerts the effects after 10 – 15 min.

Heroin starts to circulate in the bloodstream and finally crosses the blood-brain-barrier in the central nervous system (CNS) before it attaches to the opioid receptors located in the brain. The blood-brain-barrier is a protective coat that barricades against the entry of certain substances. Owing to the lipophilic nature of heroin, it can pass through this coat effectively. This exclusive property describes the potency of heroin over morphine. Once the heroin is attached to the receptors, the users will almost immediately express euphoria, feeling of warmth, contentment, detachment from emotional as well as physical distress, and relief from pain and dry mouth. Part of the effects is due to the system slowdown such as low blood pressure, slow breathing and decreased mental functioning that make the user feel relaxed. Higher doses of heroin will cause death as the entire system shifts from slowdown to shutdown. First time users may show some side effects such as nausea and vomiting. Long term use of heroin will

also cause withdrawal symptoms, dependence and tolerance because heroin is an addictive drug. The details of the pharmacological effects from using heroin are summarized in Table 2.2.

Table 2.2: Pharmacological effects of heroin in human body

Sought after effects	Short-term effects	Long-term effects
<ul style="list-style-type: none"> • Sense of well being by reducing tension, anxiety and depression; euphoria, in large doses • Warmth, contentment, relaxed detachment from emotional as well as physical distress • Relief from pain (analgesia) 	<ul style="list-style-type: none"> • Sometimes nausea and vomiting • Constricted pupils • Drowsiness, inability to concentrate, apathy, lessened physical activity • Acute overdose can result in death due to respiratory depression 	<ul style="list-style-type: none"> • Rapid development of tolerance and physical and psychological dependence • Constipation • Menstrual irregularity • Infectious diseases, abscesses, if injected • Damage of structures in nose, if sniffed/snorted • Respiratory problems, if smoked • Decreased appetite leading to malnutrition, weight loss • Chronic sedation, apathy leading to self-neglect • Abrupt withdrawal results in moderate to severe withdrawal syndrome which is generally comparable to about of influenza (with cramps, diarrhea, running nose, tremors, panic, chills and sweating, etc.)

(Source: UNODC, 2003, p. 27-28)

In fact, heroin is merely a transporter without significant pharmacological effects. The system changes heroin back to morphine almost immediately in the human

body. Therefore in forensic toxicology, in order to know whether the abuse of heroin has taken place, morphine and not heroin has to be determined (Lemos, Anderson, Valentini, Tagliaro & Scott, 2000). Heroin has a considerably short biological half-life of 3 min. It is rapidly deacetylated to 6-monoacetylmorphine. This is followed by the hydrolysis of the second acetyl group, but at a slower speed, to produce morphine. Morphine is the main ingredient in the biological system that exerts pharmacological effects. Inturrisi *et al.* (1983) recognized that this compound has a greater affinity to the opioid receptors than heroin. Morphine has a longer half-life of 2 – 3 hours which will be metabolized to morphine-3 (M3G) and morphine-6 glucuronides (M6G) and excreted as glucuronide conjugates in the liver. There is also a report attributing a great proportion of pharmacological effects to these M6G in the CNS in the use of heroin (Moore, Hand, Carroll & McQuay, 1992).

One of the rehabilitations for heroin abuse is alternative pharmacotherapy. Methadone was a legal substitution for the heroin drug addicts to abstain from heroin by reducing the severity of heroin withdrawal. Second treatment involving an opioid antagonist called naltrexone helps block both the analgesic and euphoric effects of heroin. However this has met with failure and many abusers have become dependent on the alternatives to the extent that these new substances eventually have become drugs of abuse. Thus, methadone has finally been proscribed as a dangerous drug in Malaysia.