

Forensic Analysis of Cathinones

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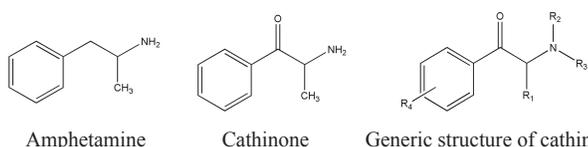
ABSTRACT: In the past decade there has been a significant increase in the popularity of synthetic cathinones in the illegal drug market. They have been easily available from Internet-based vendors as well as at “head shops” and “smart shops”. The recent prominence of synthetic cathinones can be attributed to their stimulatory properties similar to those of amphetamines. This paper provides a review on the current popular cathinone derivatives, their history and prevalence in the illegal drug market, legislation of these drugs in various countries, pharmacology, toxicology, and metabolism studies, analysis of toxicology samples (blood, urine, and hair) and criminalistic samples (seized, purchased via the Internet, and synthesized). From the reviewed literature, it is concluded that the products sold as “legal highs” do not only contain cathinone but also cathinone derivatives, and adulterants such as caffeine, lidocaine, and inorganic materials. Full toxicity data is currently unavailable for this drug class and hence more research is required with regard to their analysis and metabolism. Moreover, clandestine chemists are constantly synthesizing new derivatives and hence forensic chemists often need to synthesize and characterize these drugs to confirm the identity of the seized samples. This is expensive as well as time-consuming. Therefore, there is a need for national and international collaboration among forensic chemists to overcome this difficulty.

KEY WORDS: Legal highs, MDPV, mephedrone, methcathinone, synthetic cathinones.

INTRODUCTION

Synthetic cathinones, a class of designer drugs, are structurally and pharmacologically similar to amphetamines. Cathinone (S-2-amino-1-phenyl-1-propanone) is one of the drugs in this class that has a ketone group at the β -carbon atom to the amine in amphetamine structure (**Structure 1**). For this reason these drugs are considered as β -keto analogues of amphetamine.

Cathinone is naturally present in fresh leaves of the *Catha edulis* plant (**Figure 1**) [47]. It is cultivated in East Africa and the Arabian Peninsula. Different names have been used around the world such as “tchat” in Ethiopia, “qut” in Yemen, “qaad” or “jaad” in Somalia, “miraa” in Kenya, “mairungi” in Uganda, and “muhulo” in Tanzania [37].



Structure 1. Chemical structures of amphetamine, cathinone, and generic structure of cathinone indicating positions for structural variation.



Figure 1. *Catha edulis* plant [30].

Chewing of fresh *Catha edulis* leaves is popular in certain countries such as Yemen and Somalia [78]; the practice results in a stimulant effect similar to that experienced when amphetamine is taken [31,37,80]. Figure 1 shows the *Catha edulis* plant.

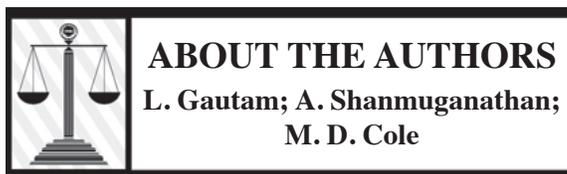
All known cathinone derivatives are either *N*-alkylated (R_2 and R_3), ring-substituted (R_4), or formed by the variation of the α -carbon substituent (R_1) (**Table 1**). There are approximately 30 known cathinone derivatives [47]. These drugs have common, IUPAC, and street names as listed in **Table 2**. For the purpose of this review, common names will be used.

Synthetic cathinones are mostly encountered as white or brown powders in both amorphous and crystalline forms. Tablet forms are less common but sometimes available in the illicit drug market (**Figure 2**). These drugs are ingested and/or insufflated, and can also be injected due to their water-soluble nature [47,76,103]. Other routes of administration include inhalation and rectal or gingival insertion. Parallel routes of administration have also been reported [111]. Mephedrone, as an example, can be

Table 1. Structural differences in selected synthetic cathinones (The substitution relates to Structure 1 [33])

Name	Functional group ^a			
	R1	R2	R3	R4
Mephedrone	Me	Me	H	4-Me
Dimethylcathinone	Me	Me	Me	H
Methedrone	Me	H	Me	4-MeO
Methylone	Me	Me	H	3,4-Methylenedioxy
Butylone	Et	Me	H	3,4-Methylenedioxy

^a Me = methyl; Et = ethyl.



Lata Gautam holds M.Sc. and B.Sc. degrees from Tribhuvan University in Nepal. She obtained her Ph.D. in forensic science in 2007 from Anglia Ruskin University (Cambridge, UK). Dr. Gautam is currently senior lecturer at Anglia Ruskin University.

Dr. Gautam has worked in the Toxicology and Chemistry Unit and the Biology and Serology Unit at the National Forensic Science Laboratory (Nepal) where she analyzed forensic case samples. Her Ph.D. research was entitled “An in vitro Investigation of Amphetamine Binding to Synthetic and Natural Melanins”. Prior to taking up her current position, she was engaged in postdoctoral research in the Environmental Sciences Research Centre under the Millennium European Climate project, also at Anglia Ruskin. Dr. Gautam’s areas of interest lie in drug binding to hair components (human and animal hair and feathers) and drug analysis from biological samples (blood, urine), drug analysis from waste water, and drug synthesis and profiling, among others. Her drug binding studies have been widely presented and published in the forensic toxicology and hair society conferences in the United States and Europe. Her recent research on piperazines profiling and toxicity has gained wide media attention (BBC, Nature, and RSC Chemistry World) and has been presented in various conferences. In addition, Dr. Gautam has published several journal articles in the drugs and toxicology subject area.

Dr. Gautam is a fellow of the Higher Education Academy (HEA), UK, since 2009. She is a member of the International Association of Forensic Toxicologists, the Society of Hair Testing, the National Forensic Society (Kathmandu, Nepal), and the Biotechnology Society of Nepal.

Anusha Shanmuganathan obtained a double degree in forensic science and criminology from Anglia Ruskin University in 2012. Ms. Shanmuganathan’s dissertation topic was entitled, “A literature review on synthetic cathinones: analytical methods and legislation.” Ms. Shanmuganathan’s current academic and career interests are in the subject areas of drugs, poisons, and data analysis. She has experience in these areas through completing a summer internship at Anglia Ruskin in 2012.

Michael D. Cole graduated in 1986 with a B.Sc. degree in natural sciences from the University of Cambridge (Cambridge, UK). He obtained his Ph.D. from the University of London (London, UK) in 1990 in natural product chemistry. Having been head of the Department of Forensic Science and then of the Department of Life Sciences at Anglia Ruskin University, Dr. Cole was appointed director of research and scholarship in the Faculty of Science and Technology there since April 2010.

Prof. Cole has a longstanding interest in drug analysis. At present his research interests lie in development of analytical techniques for the newly controlled and recently developed amphetamine-type stimulants and an investigation of the degree and mechanisms of toxicity of the drugs and their impurities. The former work has been widely published and presented in the United States, Europe, and Asia. The latter work on drug toxicity has been the subject of broadcasts by the BBC television and local radio stations, and has been the subject of articles in the journals, such as *Nature* and *Chemistry World*, along with numerous newspaper reports. Dr. Cole has authored several books, book chapters, and journal articles.

Prof. Cole was the inaugural chair of the European Network of Forensic Science Institutes working group on drugs. He was the lead assessor for the Council for the Registration of Forensic Practitioners drugs section. He currently is a member of the equivalent panel working for the Dutch government. He led a European Consortium, funded under the EU Framework V program, to develop a harmonized method for the profiling of amphetamines. The result of this work is a method that is now used all over the world.