Sensing and Bio-Sensing Research 13 (2017) 28–39

Contents lists available at ScienceDirect

Sensing and Bio-Sensing Research

journal homepage: www.elsevier.com/locate/sbsr

Extending the capability of forensic electrochemistry to the novel psychoactive substance benzylpiperazine

S.A. Waddell [a,*], C. Fernandez [a], C.C. Inverarity [a], R. Prabhu [b]

[a] School of Pharmacy and Life Sciences, Robert Gordon University, Garthdee Road, Aberdeen AB10 7GJ, United Kingdom
[b] School of Engineering, Robert Gordon University, Garthdee Road, Aberdeen AB10 7GJ, United Kingdom

ARTICLE INFO

Article history:
Received 8 July 2016
Received in revised form 9 December 2016
Accepted 16 December 2016

Keywords:
Voltammetry
Forensic
Controlled drugs
Benzylpiperazine
Ecstasy

ABSTRACT

Benzylpiperazine (BZP) is a novel psychoactive substance that is commonly abused in tablet form as an "ecstasy-type" drug. Electroanalysis offers genuine potential for field testing of bulk drug samples. This research is the first to investigate the viability of voltammetric analysis of BZP. Initial cyclic voltammetry in 0.1 M KCl showed an oxidative peak at a glassy carbon electrode for BZP at approximately 0.8 V (scan rate 205 mV s^{-1}). Next an optimised electrode/electrolyte combination (viz. 80:20 W:W glassy carbon beads:nujol and pH 9.5, 40 mM, Britton-Robinson buffer) was developed using $K_3Fe(CN)_6$ to test the electrode material. The oxidation of BZP involves two electrons and two protons and a mechanism has been proposed. An anodic stripping square wave voltammetric method was optimised by factorial design with the conditions of deposition: −0.8 V for 135 s, and stripping: step height 10 mV, amplitude 50 mV and frequency 13 Hz. A limit of detection of 6 μM was achieved. The resolution against 3,4-methylenedioxymethylamphetamine (MDMA) was also verified.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

The abuse of ecstasy tablets came to prominence across Europe during the late 1980′s at which time the major active ingredient was 3,4-methylenedioxymethylamphetamine (MDMA) [1]. However over the years clandestine laboratories have sought to circumvent the law by producing tablets containing compounds which were not under control. This has led to an enormous range of compounds being seized worldwide. In fact, the 2015 World Drugs Report estimates 500 compounds are abused globally [2]. In order to deal with such a vast issue the United Kingdom introduced the Psychoactive Substances Act 2016 wherein such a substance was defined as that which "produces a psychoactive effect in a person if, by stimulating or depressing the person's central nervous system, it affects the person's mental functioning or emotional state" [3]. Although the substances are defined by their action rather than their structure, there are broad families of compounds which are commonly encountered namely: aminoindanes, synthetic cannabinoids, cathinones, ketamine and phencyclidine-types, phenethylamines, piperazines and tryptamines [4]. Further to this, the generality of the terminology in the legislation enables law enforcement to seize any New Psychoactive Substances (NPSs), as they are commonly known, resulting in a wide array of compounds which are presented for analysis to forensic agencies. An excellent overview which outlines the recent analytical strategies undertaken is given by Smith et al. [5].

Benzylpiperazine (BZP) is one such NPS, structure shown in Fig. 1. The importance of BZP in Europe was first noted in the early part of the 21st century as it was being sold as a "legal high" over the internet [6]. There was also some confusion at the time with piperazines being sold as "herbal highs" although they are entirely synthetic. This may have been due to structural similarities with the pepper derived compound piperidine [7]. Then in 2009 the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) advised that the member states should control BZP stating: "due to its stimulant properties, risk to health, the lack of medical benefits and following the precautionary principle, there is a need to control BZP, but the control measures should be appropriate to the relatively low risks of the substance" [8]. In the UK, BZP and structurally related analogues were brought under control of the Misuse of Drugs Act 1971, being listed as Class C in 2009 [9].

There already exists a wide array of chromatographic analytical methodologies in the scientific literature regarding the analysis of BZP. A brief synthesis of the analysis of BZP in a range of matrices is shown in Table 1. Typical limits of detection (LOD) tend to be in the nanomolar range, and this is indeed necessary for the analysis

* Corresponding author.
E-mail address: s.waddell1@rgu.ac.uk (S.A. Waddell).

http://dx.doi.org/10.1016/j.sbsr.2016.12.001
2214-1804/© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

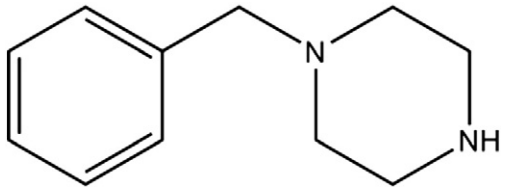

Fig. 1. Structure of benzylpiperazine (BZP).

of clinical samples and wastewater, however it should also be noted that the methods are normally accompanied by a prior extraction step in order to attain LOD values in this range. It is also noteworthy that expensive, lab based instrumentation is required for this type of analysis which makes it unsuitable for field testing of bulk drugs.

Consequently a number of presumptive tests have been developed that can detect the presence of BZP. One such novel presumptive spot test was developed by Philp et al. [10] using sodium 1,2-naphthoquinone-4-sulphonate to produce a dark red colour for BZP. The proposed reaction scheme for this test is shown in Fig. 2. They subjected the test to rigorous validation against many active ingredients and excipients commonly found in ecstasy-type seizures and were also able to determine an LOD of 40 μg, which is more than sensitive enough for its purpose. Piperidine has long been known to be a precursor for phencyclidine [11] and as such has been monitored closely. In a United Nations Scientific and Technical Note the formation of a blue-coloured Simon-Awe complex is described, as shown in Fig. 3 [12]. Almost all piperazines contain the same active moiety as piperidine and as such this general test for secondary amines could be applied. It is in fact the amine functionality that enables colorimetric detection for all the common presumptive tests [6].

Microcrystalline identification does not offer as low an LOD as the colorimetric spot tests, but the growing habits that are observed between reagents and drugs can be very specific [13]. Elie et al. [14] designed a microcrystalline assay for BZP using mercury chloride as the reagent. Upon gentle mechanical assistance for nucleation, BZP was found to form distinctive rectangular plates.

Table 1
Chromatographic analytical methodologies for the analysis of BZP.

Matrix	Extraction and derivatisation	Analytical conditions	Limit of detection	Reference
Urine	Enzymatic hydrolysis with 100 mM acetate buffer containing sulfatase/β-glucuronidase, then solid phase extraction with Oasis HLB	Liquid Chromatography: SCX column (150 mm × 2 mm); 40 mM pH 4 Acetate Buffer:MeCN 25:75 v:v at 0.15 mL min^{-1}; Shimadzu LCMS 2010A mass analyser	30 nM	[33]
		Gas Chromatography: DB-5MS column (30 m × 0.25 mm × 0.25 μm); He 1.0 mL min^{-1}; Shimadzu GCMS QP-2010 mass analyser	300 nM	
Tablets and capsules	10 min ultrasonication in 20 mM HCl:MeOH 1:1 v:v	Liquid Chromatography: L-column ODS or SymmetryShield R_{18} (150 mm × 4.6 mm × 5 μm); 10 mM SDS in MeCN:H_2O:H_3PO_4 300:700:1 v:v:v at 1 mL min^{-1}; Diode array detector at 199–360 nm	Not given	[34]
		Gas Chromatography: DB-5MS column (30 m × 0.25 mm × 0.25 μm); He 1.1 mL min^{-1}; Agilent N3520 mass analyser	Not given	
Plasma and urine	Centrifugation then deproteinized with 35% $ZnSO_4$ plus enzymatic hydrolysis of urine	Liquid Chromatography: Zorbax C18 column (150 mm × 4.6 mm × 5 μm); gradient using 0.01 M pH 4.5 NH_4CHOO and MeCN at 1 mL min^{-1}; Agilent MSD model D single stage quadrupole mass analyser	30 nM	[35]
Plasma	Dilution with pH 6 Phosphate buffer then solid phase extraction using Chromabond Drug	Liquid Chromatography: Synergi Polar RP column (150 mm × 2 mm × 4 μm); gradient using 0.1% CHOOH in 1 mM NH_4CHOO and 0.1% CHOOH in MeOH at 0.25 mL min^{-1}; Sciex API 365 tandem mass analyser	30 nM	[36]
Simulated Wastewater	Filtration the SPE using XRDAH506	Liquid Chromatography: Luna pentafluorophenyl column (50 mm × 4.6 mm × 3 μm); gradient using MeOH and 0.1% CHOOH at 0.5 mL min^{-1}; AB Sciex Q-Trap mass analyser	6 pM	[37]
Simulated tablets	Dilution only for liquid chromatography and heptafluorobutyric acid derivatisation and silylation using SilPrep for gas chromatography	Liquid Chromatography: Hypersil C18 column (125 mm × 3 mm × 3 μm); gradient using pH 3.2 PB and MeCN at 0.4 mL min^{-1}; DAD at 210 to 400 nm	50 μM	[38]
		Gas Chromatography: heptafluorobutyric acid derivatisation and silylation using SilPrep®; HP-5MS column (30 m × 0.25 mm × 0.25 μm); He 1.0 mL min^{-1}; Agilent 5971A mass analyser	3 μM	
Urine	Liquid/liquid extraction using KOH	Gas Chromatography: pentafluoropropionic anhydride derivatisation; J&W column (20 m × 0.18 mm × 0.18 μm); He 1.0 mL min^{-1}; Agilent 5975 mass analyser	150 nM	[39]
Urine	Centrifugation then solid phase extraction using SOLA SCX	Liquid Chromatography: Accucore C18 (100 mm × 2.1 mm × 2.6 μm); gradient elution using 0.1% HCOOH in water and 0.1% HCOOH in MeCN at 0.4 mL min^{-1}; Thermo Scientific NCS-3500RS UltiMate 3000 Binary Rapid system coupled to a Thermo Scientific Q Exactive Mass spectrometer	6 nM	[40]
Hair	Overnight sonication in 0.1% HCOOH	Liquid Chromatography: Kinetex C18 column (100 × 2.1 mm × 2.6 μm); gradient elution using 0.1% HCOOH in 5 mM NH_4HCOO and 0.1% HCOOH in 1:1 v:v MeOH: MeCN at 0.35 mL min^{-1}; Agilent 6460 triple quadrupole mass spectrometer	5 pg/mg of hair	[41]
Tablets	Dissolution in water then freeze dried overnight	Liquid Chromatography: Synergi Hydro-RP Phenomenex column (250 mm × 10 mm); gradient elution using 0.05% CF_3COOH in water and MeCN at 3 mL min^{-1}; UV detection at 208 nm	Not given	[42]
		Gas Chromatography: DB1-ms column (15 m × 0.25 mm × 0.25 pm sic); He 2 mL min^{-1}; Agilent 5975C MSD Series with a Triple-Axis Detector	Not given	
Tablets	Unltrasonication in 2-methyl-propan-2-ol then centrifugation	Gas Chromatography: Supelco Equity 5 column (30 m × 0.25 mm × 0.25 μm); He 1 mL min^{-1}; Perkin Elmer Clarus Turbomass Gold 500MS detector.	2 nM	[43]
Wastewater	Solid phase extraction using Oasis MCX.	Gas Chromatography: Pentafluoropropionic anhydride derivatisation; Supelco Equity TM-5 column (30 m × 0.25 mm × 0.25 μm); He 1 mL min^{-1}; PerkinElmer Clarus 500 Gas Chromatograph-Mass Spectrometer detector	0.14 pg on column	[44]

Download English Version:

https://daneshyari.com/en/article/5019638

Download Persian Version:

https://daneshyari.com/article/5019638

Daneshyari.com