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Ionic liquid-supported Cuo-ROD nanocomposite by dispersive solid phase extraction for sample preparation of some phthalates in bottled water

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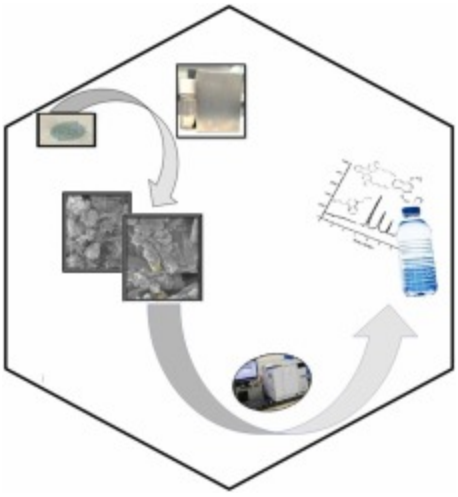
Highlights

- Development of a new adsorbent for dispersive solid phase extraction.
- The amount of phthalates in water bottles was in the range of 8.9–195.3μg/L.
- The detection limit of the method was in the range of 0.78–1.25μg/L.
- The quantitative limit of the method was in the range of 2.57–4.12μg/L.

Abstract

Release of phthalates as a plastics additive from bottles to drinking water is a source of risk. A novel dispersive solid phase extraction (DSPE) with dual polarity was prepared for trace analysis of some phthalates. Adsorbent consisted of magnetic nano silica aerogel (MSi) coated by CuO ROD (CuR) which was supported with ionic liquid (IL). Produced MSi@CuR@IL was characterized by SEM, VSM, BET, EDS, FTIR, C/H/N elemental analysis and TGA. According to results, optimized condition was evaluated in 24mg MSi@CuR@IL, sample absorption time of 14min at pH=6.2 by suspension speed of 700 RPMI. Using optimized method suitable performance was presented including detection limit of 0.78–1.25µg/L, with recovery of 92.21–102.12 and repeatability of <10 %. Evaluated DSPE was performed in 10 plastic bottled water between 8.9 and 195.3µg/L. Finally, simultaneous application of CuR on the surface of MSi as a polar section and IL with polar and nonpolar properties were provided a potent DSPE for phthalates determination. Designing two-side properties for attraction polar and nonpolar fragment is the advantage of suggested DSPE. Accordingly, a simple and rapid method has been developed for trace monitoring of di (2-ethylhexyl) phthalate (DEHP), dimethyl phthalate (DMP) and diethyl phthalate (DEP) in bottled water. Not assessing of different type of phthalate is the limitation of our study

Graphical Abstract



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Introduction

Modern lifestyle and population growth cause emerging contaminants into the food, drinking water and environments (Gao et al., 2020, Lian et al., 2020, Wu et al., 2021).

Pharmaceuticals, phthalates, micro plastics and surfactants are some of major emerging contaminants in different media (Herrero et al., 2012). These chemicals are defined as new chemicals with considerable potential for human health by Environmental Protection Agency (EPA) (Parlapiano et al., 2021). Emerging contaminants are found in trace level, but their accumulation in the environment is a hurdle of chemical risks (Pastorino & Ginebreda, 2021). Phthalates are an important group of emerging contaminants due to various applications in polyvinyl chloride, toys, personal care products, and medical products (Bu et al., 2019).

Phthalates are a group of polymer plasticizer applied to improve the flexibility of products. These reagents are characterized by endocrine disruption and estrogenic effects in human health (Dogaheh and Behzadi, 2019, Hadjmohammadi and Ranjbari, 2012). Di-(2- Ethyl hexyl) phthalate has been classified as a possible carcinogen to human by International Agency for Research on Cancer (Abtahi et al., 2019). Phthalates commonly used in food packaging, plastic bottle of juice and water bottle (Akhbarizadeh et al., 2020, Fierens et al., 2012). Low molecular weight of phthalates cause significant release of these components in plastic packaging materials (Paluselli et al., 2018). Therefore, proposing a method for trace determination of phthalates in drinking water seems interesting.

For phthalates evaluation, some methods developed according to gas chromatography techniques with electron capture (EC) detector and mass spectrometry (MS) detector (US Environmental Protection Agency EPA, 1996; Moazzen et al., 2018; Wang, et al., 2021). Noise disruption of EC detector, deserves special mention while MS detector is expensive. Moreover, correct application of EC and MS detector is experience-dependent. This disadvantage is the reason of non-commercial use for EC and MS detection.

To determine low concentration of phthalates, various solid phases have been suggested, including microsphere, polyaniline coated chitosan nanocomposite, and ZIF-8 in different samples (Liang et al., 2019, Lu et al., 2019, Razavi and Es' haghi, 2018). Application of magnetic nanocomposite in sample preparation is the advantage of these suggestions. External magnetic field enhanced a simple extraction with the highest efficiency in a short period (Herr et al. 2006).

One-dimensional materials such as rods and tubes as a functional material with super properties are intended (Viswanathamurthi et al., 2003). These structures are specified by high mechanical strength, exorbitant surface area and suitable electron transportation (Boddula et al., 2019). Carbon tube and metal oxides rods are the most intensively one-dimensional materials improved in recent years (Wang and Gao, 2003, Yuan and Müller, 2010). Growing of the rods on the surface of material is a unique property to produce

heterogenic structure and improve surface area for efficient extraction (Ilipronti et al., 2019). CuO is specified by great surface area, physiochemical stability and low cost of preparation (Boddula et al., 2019). Therefore the study of CuO ROD (CuR) has received significant attention recently (Araghi et al., 2017, Pallela et al., 2019).

Ionic liquids (IL) are a new solvent mainly used to improve the characteristic of solid phase. These materials are attractive due to dual nature of their structure including low polarity properties and powerful proton donor groups (Vidal et al., 2012). Hydrophilicity and hydrophobicity potential of IL are increased reports for the application of these components in adsorption process. This behavior causes the application of IL in the sample preparation techniques (Liu et al., 2019, Tian et al., 2019, Wang et al., 2019). Determination of phthalates in trace level released from plastic bottle in aqueous samples has great applicability in health risk assessment. The aim of this study is developing an efficient adsorbent for the sample preparation of dimethyl phthalate (DMP), diethyl phthalate (DEP) and di-2-ethylhexyl phthalate (DEHP) in water sample. Additive properties of structures in a Nano composite of magnetic silica aerogel and CuO rods supported by an ionic liquid (MSi@CuR@IL) is the novel aspect of this work which could be employed for unique sample preparation of phthalates in bottled samples.

Section snippets

Chemicals

Nano silica aerogel prepared by Vakonesh Sanate Part Co., Ltd (Esfahan, Iran). Di (2-ethylhexyl) phthalate (DEHP, C24H38O4,CAS number 117-81-7, purity ≥ 99.0 %), dimethyl phthalate (DMP, C10H10O4, CAS Number 131-11-3, purity ≥ 99.0 %), diethyl phthalate (DEP, C12H14O4,CAS number: 84-66-2, purity ≥ 99.0 %), 1-butyl-3-metylimidazolium tetrafluoroborate (CAS number 174501-65-6, purity ≥ 99.0 %), hexamethylenetetramine (CAS number 100-97-0, purity ≥ 99.0 %), ferric chloride hexahydrate (CAS No.…

Nanocomposite characterization

MSi@CuR@IL is proposed in this study for the first time. As presented in Fig. 1 magnetic properties of silica aerogel was performed through chemical co-precipitation reaction. Moreover, hydrothermal strategy in the presence of copper sulphate, MSi and IL was used for MSi@CuR@IL production.

Fig. 2 specified the SEM, Elemental analysis of C/H/N, VSM, TGA, BET and FTIR character of synthetized nanocomposite. The morphology of prepared MSi@CuR@IL was characterized by SEM technique. Image in Fig. 2a, …

Conclusion

Widely application of plastic packing for bottled water is an import hurdle in drinking water consumption. Thus, trace analysis of released phthalates in drinking water was a strong reason for this study. Synthetize of efficient adsorbent and application of commercial technique are the advantages of present research. An adsorbent was synthetized with two-side properties for attraction of polar and nonpolar fragment of phthalates according to gas chromatography equipped with flame ionization…

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CRediT authorship contribution statement

Omidi Ali: Visualization, Methodology, Validation and Writing – original draft. **Zendehdel Rezvan:** Conceptualization, Methodology, Writing – review & editing, Project administration and Funding acquisition. **Khaloo Shokooh Sadat:** Data curation, Investigation. **Ravannakhjavani Fatemeh:** Software**. Khodakarim Soheila:** Formal analysis. **Ghanbari kakavandi Masoud:** Resources. **Ashrafi Barzideh Siamak:** Writing – review & editing.…

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Zendehdel Rezvan reports financial support was provided by Shahid Beheshti University of Medical Sciences, Tehran, Iran.…

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References (44)

M. Abtahi *et al.*
Health risk of phthalates in water environment: occurrence in water resources, bottled water, and tap water, and burden of disease from exposure through drinking water in Tehran, Iran
Environ. Res. (2019)

R. Akhbarizadeh *et al.*
Worldwide bottled water occurrence of emerging contaminants: a review of the recent scientific literature
J. Hazard. Mater. (2020)

M.M. Alshehri *et al.*
Determination of phthalates in bottled waters using solid-phase microextraction and gas chromatography tandem mass spectrometry
Chemosphere (2022)

M. Araghi *et al.*
Synthesis and investigation of antimicrobial properties of SiO2@ Cu rods with core–shell structure
J. Environ. Chem. Eng. (2017)

Z. Bu *et al.*
Exposure to commonly-used phthalates and the associated health risks in indoor environment of urban China
Sci. Total Environ. (2019)

E.S. Chen *et al.*
Electron-capture detector and multiple negative ions of aromatic hydrocarbons
J. Chromatogr. A (2002)

N. Chunin *et al.*

A novel 3D-printed solid phase microextraction device equipped with silver-polyaniline coated pencil lead for the extraction of phthalate esters in cosmeceutical products
Anal. Chim. Acta (2019)

S.A. Dharaskar *et al.*
Synthesis, characterization and application of 1-butyl-3-methylimidazolium tetrafluoroborate for extractive desulfurization of liquid fuel
Arab. J. Chem. (2016)

T. Fierens *et al.*
Analysis of phthalates in food products and packaging materials sold on the Belgian market
Food Chem. Toxicol. (2012)

O. Herrero *et al.*
Toxicological evaluation of three contaminants of emerging concern by use of the Allium cepa test
Mutat. Res./Genet. Toxicol. Environ. Mutagen. (2012)