Data Article

Enhanced electro kinetic- pseudo-Fenton degradation of pyrene-contaminated soil using Fe₃O₄ magnetic nanoparticles: A data set

Fatemeh Asgharzadeh a, Masoud Moradi b, Ahmad Jonidi Jafari c,d, Ali Esrafil d, Mahsa Tahergorabi d, Roshanak Rezaei kalantari c,d,*

a Department of Environmental Health Engineering, School of Public Health, International Campus, Iran University of Medical Sciences, Tehran, Iran
b Research Center for Environmental Determinants of Health, Kermanshah University of Medical Sciences, Kermanshah, Iran
c Research Center for Environmental Health Technology, Iran University of Medical Sciences, Iran
d Department of Environmental Health Engineering, School of Public Health, Iran University of Medical Sciences, Tehran, Iran

A R T I C L E   I N F O

Article history:
Received 6 September 2018
Received in revised form 7 November 2018
Accepted 14 November 2018
Available online 20 November 2018

Keywords:
EK-pseudo-Fenton process
Soil
Fe₃O₄ nanoparticle

A B S T R A C T

The aim of the data were to increase the treatment efficiency of pyrene from soil using Nano catalysts magnetite iron oxide (Fe₃O₄) and combined with electro kinetic. Soil provided with 100 mg/kg concentration and removal of pyrene done with EK-Fenton process. Nano catalyst was synthesized via a facile co-precipitation method and characterized by FTIR, XRD, SEM, EDX, VSM techniques. The effects of some operational parameters include catalyst dosage, pH, hydrogen peroxide concentration and the voltage were studied on the removal efficiency of pyrene. Results indicated the removal efficiency was obtained 87% under optimal conditions (pH = 3, Nano catalyst dosage = 1 g/l, H₂O₂ = 10 mM and voltage 30 V). Electrokinetic Fenton process can be as efficient and effective method for the removal of pyrene from contaminated soil using Nano Catalyst Fe₃O₄ introduced in optimal conditions.

© 2019 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Specifications table

| Subject area | Environmental engineering |
|--------------|----------------------------|
| More specific subject area | Environmental Chemistry |
| Type of data | Tables, image, graph, figures, text file |
| How data were acquired | Pyrene was extracted from the soil texture into acetone solvent. Residual of pyrene was determined using a gas chromatography (GC) equipped with a flame ionization detector and a column C18 with dimensions (5 lm, 250 mm long × 4.6 mm ID). The characteristics of catalyst were conducted by FTIR, XRD, SEM, EDX, VSM techniques. |
| Data format | Raw, analyzed |
| Experimental factors | All samples were kept in polyethylene bottles in a dark place at room temperature. |
| Experimental features | The all above mentioned parameters were analyzed according to the standard method for water and wastewater treatment handbook |
| Data source location | North of Iran |
| Data accessibility | Data are included in this article |
| Related research article | N/A |

Value of the data

- Pyrene with low biodegradability and high persistency in environment, which is considered as a priority pollutant by US EPA because of its carcinogenic and mutagenic effects therefore applying the proper technology is the need to remove Pyrene and decreasing of its concern.
- Electrokinetics process is a clean and effective technology for removal of pyrene in the contaminated soil.
- Modified Fenton with Fe₃O₄ nanoparticle is more effective than standard Fenton (iron salt) due to increasing of Fenton process capability to break down the toxic and hazardous substances (pyrene).
- According to the data include in this data article and the considerable benefits obtained from the use of Electrokinetics, including polycyclic aromatic hydrocarbon-contaminated sites.

1. Data

Table 1 indicated properties of pyrene. Table 2 showed the characteristics of sandy clay soil. As shown clay is the most compound of soil texture. Fig. 1 illustrated X-ray diffraction (XRD) of Fe₃O₄ (a) Fourier transform infrared spectroscopy (FT-IR) of Fe₃O₄ (b) EDX image of Fe₃O₄ (c), SEM image of Fe₃O₄ and (e) VSM of Fe₃O₄ (d). Fig. 2 depicted the effect of pH on the removal of pyrene in soil by electrokinetic-Fenton process (Fe₃O₄ = 0.5 g/l, H₂O₂ = 10 mM, voltage = 30 V). Fig. 3 showed the effect of

| Name         | Chemical formula | Structure | Molar mass (g/mol) | Density (g/ml) | Melting point (°C) | Boiling point (°C) | Solubility (mg/l) |
|--------------|------------------|-----------|--------------------|----------------|--------------------|--------------------|-------------------|
| Pyrene      | C₁₆H₁₀           | ![Pyrene](image) | 202.25             | 1.271          | 145–148            | 404                | 0.135             |
Table 2
Characteristics of sandy clay soil.

| Characteristics       | Soil     | Value | %  |
|-----------------------|----------|-------|----|
| Texture               | Sandy loam | –     |    |
| Clay                  | 50       |       |    |
| Sand                  | 44       |       |    |
| Silt                  | 6        |       |    |
| pH                    | 8        |       |    |
| Electrical conductivity | $5 \times 10^{-7}$ | Ms/m  |    |
| Soil moisture         | 4.8      |       |    |
| Organic matter        | 0.3      |       |    |
| Organic carbon        | 0.17     |       |    |
| Iron                  | 6.3      | ppm   |    |

Fig. 1. X-ray diffraction (XRD) of Fe$_3$O$_4$, (a) Fourier transform infrared spectroscopy (FT-IR) of Fe$_3$O$_4$, (b) EDX image of Fe$_3$O$_4$, (c) SEM image of Fe$_3$O$_4$ and (e) VSM of Fe$_3$O$_4$.

of H$_2$O$_2$ concentration on the removal of pyrene in soil by electrokinetic-Fenton process (Fe$_3$O$_4$=0.25 g/l, voltage = 30 V). Fig. 4 indicated the effect of Fe$_3$O$_4$ nanocatalytic concentration on the removal of pyrene in soil by electrokinetic-Fenton process (H$_2$O$_2$= 10 mM, voltage = 30 V). Fig. 5 depicted the effect of current voltage on the removal of pyrene in soil by electrokinetic-Fenton process (Fe$_3$O$_4$= 1 g/l, H$_2$O$_2$=10 mM). Fig. 6 showed the effect of contact time on the removal of pyrene in soil by electrokinetic-Fenton process (Fe$_3$O$_4$=0.5 g/l, H$_2$O$_2$= 10 mM, voltage = 30 V).
2. Materials and methods

2.1. Materials

Pyrene was purchased from Merck. The properties of pyrene were shown in Table 1. The acetone [(C3H6O, Assay 99.8%, MW: 58.08 g/mol, Density: 0.791 g/cm\(^3\)] as a solvent purchased from Merck company.

2.2. Characteristics of soil

20–30 cm below ground surface of soil were collected from the north of Iran. Sample were dried in the ambient sieved (No. 10 mesh)\(^1\). Sandy clay soil with various characteristics listed in Table 2. Contaminated soil was prepared and mixed by a pyrene stock solution of 100 mg/l at 200 rpm for 3 h\(^2\).

2.3. EK-Fenton reactor

The set-up of EK-Fenton was conducted as follow: Four components electrode are made of aluminum with the distance of 1 cm. The slurry of soil column with 1/10 ratio was made in Pyrex glass (2000cc). A power supply was connected to the electrodes to provide direct current for EK-Fenton treatment in flow (0–3) A and voltage (0–60) V. The clamp of the adaptor connected from one side to the positive (+) and negative (−) pole device power supply and the other side connected to the
electrodes. So electrodes connected to the positive pole will role of anode and electrodes attached to the negative pole will role of cathode [3–7].

2.4. Synthesis of Fe₃O₄ magnetic nanoparticles

The Fe₃O₄ were prepared using the co-precipitation method. The certain amount of FeCl₃·6H₂O and FeCl₂·4H₂O were dissolved in 200 ml deionizer water. NH₄OH 25% (25 ml) was added drop-wise to the precursor solution to obtain an alkaline medium (pH = 8) that led to producing a black and gelatinous precipitate of Fe₃O₄ nanoparticles under nitrogen gas. Sample was heated at 80 °C for 2 h with continuous stirring. The desired Fe₃O₄ nanoparticles were collected by a permanent magnet and then washed with deionized water and ethanol for five times. Then it was dried at 80 °C in vacuum for 5 h [8–13].

2.5. Characteristics of Fe₃O₄ magnetic nanoparticles

Fourier transform infrared spectroscopy (FTIR) Model WQF-510 was applied for determine the functional groups of nanoparticle, the chemical characteristics and surface morphology of was determined using X-ray diffraction (XRD) model Shimadzu XRD-6000. Scanning electron microscope (SEM) model Philips XL30 was used to study the surface properties of nanoparticle. The elemental analysis of nanoparticle was determined with Energy Dispersive X-Ray Spectroscopy (EDS) model.
EM-30AX Plus. Magnetization measurements were conducted by a vibrating sample magnetometer (VSM, 7400, Lakeshore, USA) [14–19].

2.6. Soil contamination with pyrene

Soil was unnaturally contaminated with pyrene solution completely dissolved in a mixture of acetone. Acetone was applied because of the low solubility of pyrene in water. The samples shacked with an orbital shaker and then placed under a ventilation hood until the solvents completely evaporated. Finally, since a portion of the pyrene may be volatilized along with the acetone, a sample was taken to determine the accurate initial concentration of pyrene in the soil. On the other hand, water was used to prepare electrical conductivity in the electrokinetic reactor. The contaminated soil was thoroughly mixed with a measured amount of water in a glass beaker so that the soil water content would be adjusted [20,21].

2.7. Analysis

Sample preparation for analyses of pyrene concentrations was conducted as follows: 2 g of sample was mixed with 10 ml of acetone in a glass beaker. The samples were shaking for the complete mixing of contaminated soil and transferred into the ultrasonic (BANDELIN SONOPULS- Germany) for 2 min to collect the organic compounds extracted from the soil texture into acetone solvent. The glass tubes were centrifuged at 4000 rpm for 60 min. Pyrene extracts were measured using a gas chromatography (GC) equipped with a flame ionization detector and a column C18 with dimensions (5 lm, 250 mm long × 4.6 mm ID). Nitrogen as a carrier gas was used to make-up flow at a constant pressure of 25 ml min⁻¹. The oven temperature was held at 100 °C for 3 min and then increased at 15 °C per minute to a final temperature of 280 °C [22–24].

Acknowledgements

The authors wish to warmly acknowledge the invaluable cooperation and support from the Iran University of Medical Sciences.
References

[1] W. Ling, L. Ren, Y. Gao, X. Zhu, B. Sun, Impact of low-molecular-weight organic acids on the availability of phenanthrene and pyrene in soil, Soil Biol. Biochem. 41 (2009) 2187–2195.

[2] S.E. Hashemi, A. Rezaee, S.M. Mosavi, M.R. Nikodel, H. Anjidoust, Pyrene removal from contaminated soil using electro-kinetic process combined with surfactant, ISMJ 18 (2015) 516–526.

[3] D. Li, X.Y. Tan, X.D. Wu, C. Pan, P. Xu, Effects of electrolyte characteristics on soil conductivity and current in electrokinetic remediation of lead-contaminated soil, Sep. Purif. Technol. 135 (2014) 14–21.

[4] G.C.C. Yang, C. Liu, Remediation of TCE contaminated soils by in situ EK-Fenton process, J. Hazard. Mater. 85 (2001) 317–331.

[5] G. Venny, N.G. Suyin, K. Hoon, Current status and prospects of Fenton oxidation for the decontamination of persistent organic pollutants (POPs) in soils, J. Chem. Eng. 213 (2012) 295–317.

[6] Z. Rahmatinia, M. Rahmatinia, Removal of the metronidazole from aqueous solution by heterogeneous electro-Fenton process using nano–Fe3O4, Data Brief (2018) 2139–2145.

[7] L. Ren, H. Lu, L. He, Y. Zhang, Enhanced electrokinetic technologies with oxidation reduction for organically-contaminated soil remediation, Chem. Eng. J. 247 (2014) 111–124.

[8] M. Moradi, O.B. Naeej, A. Azaria, A.M. Bandpei, A.J. Jafari, A. Esfandi, R.R. Kalantary, A comparative study of nitrate removal from aqueous solutions using zeolite, nZVI-zeolite, nZVI and iron powder adsorbents, Desalin. Water Treat. 74 (2017) 278–288.

[9] M.H. Dehghani, Z.S. Niasar, M.R. Mehrinia, M. Shayeeghi, M.A. Al-Ghouti, B. Heibati, G. McKay, K. Yetilmsezoy, Optimizing the removal of organophosphorus pesticide malathion from water using multi-walled carbon nanotubes, Chem. Eng. J. 310 (310) (2017) 22–32.

[10] A. Azari, M. Salari, M.H. Dehghani, M. Alimohammadi, H.R. Ghaffari, K. Shariﬁ, N. Shariatifar, M. Bazarj, Efficiency of magnetized graphene oxide nanoparticles in removal of 2, 4-dichlorophenol from aqueous solution, J. Mazandaran Univ. Med. Sci. 26 (144) (2017) 265–281.

[11] J. Jaafari, M.G. Ghozikali, A. Azari, M.B. Delkhosh, A.B. Javid, A.A. Mohammad, S. Agarwal, V.K. Gupta, M. Sillanpää, A. Javid, T. Khorasani, Magnetic adsorption separation process: an alternative method of mercury extracting from aqueous solution using modified chitosan coated Fe3O4 nanocomposites (Jan 1), Chem. Technol. Biotechnol. 92 (1) (2017) 188–200.

[12] R.R. Kalantary, M. Farzadkia, M. Kermani, M. Rahmatinia, Heterogeneous electro-Fenton process by Nano-Fe3O4 for catalytic degradation of amoxicillin: process optimization using response surface methodology, J. Environ. Chem. Eng. 6 (2018) 4644–4652.

[13] S.S. Agarwal, I. Tyagi, V.K. Gupta, M.H. Dehghani, J. Jaafari, D. Balarak, M. Asif, Rapid removal of noxious nickel (II) using novel γ-alumina nanoparticles and multiwalled carbon nanotubes: kinetic and isotherm studies, J. Mol. Liq. 224 (2016) 618–623.

[14] M. Pirsaheb, H. Mohammad, M. Moradi, Survey of effective parameters on efficiency of scoria as a low cost adsorbent for removal of nitrate from aqueous solution, Int. J. Pharm. Technol. 8 (4) (2016) 22773–22780.

[15] H.N. Saleh, M.H. MH, R. Nabizadeh, A.H. Mahvi, F. Hossein, M. Ghaderpoori, M. Youseﬁ, A. Mohammad, Data on the acid black 1 dye adsorption from aqueous solutions by low-cost adsorbent-Cerastoderma lamarcki shell collected from the northern coast of Caspian Sea, Data Brief 17 (2018) 774–780.

[16] M. Youseﬁ, S.M. Arami, H. Takallo, M. Hosseini, M. Radfar, H. Soleimani, A.A. Mohammad, Modiﬁcation of pumice with HCl and NaOH enhancing its ﬂuoride adsorption capacity: kinetic and isotherm studies, Hum. Ecol. Risk Assess. Int. J. 24 (2018) 623–633.

[17] A.A. Mohammad, M. Farzadkia, M. Kermani, M. Rahmatinia, Heterogeneous metal-organic framework Uio-66 for adsorption of methylene blue dye from aqueous solutions (2017), Int. J. Environ. Sci. Technol. 14 (2017) 1959–1968.

[18] M.H. Dehghani, S. Kamalian, M. Shayeeghi, M. Youseﬁ, Z. Heidarinejad, S. Agarwal, V.K. Gupta, High-performance removal of diazinon pesticide from water using multi-walled carbon nanotubes, Microchem. J. 145 (2018) 486–491 http://dx.doi.org/10.1016/j.microc.2018.10.053.

[19] T. Alcantara, M. Pazos, S. Gouveia, C. Cameselle, M.A. Sanromán, Remediation of phenanthrene from contaminated kaolinite by electroremediation-Fenton technology, J. Environ. Med. Sci. 26 (144) (2017) 265–281.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.11.068.
[21] S. Jorfi, A. Rezaee, N. Jaafarzadeh Haghighifard, G.A. Moheb-ali, Application of Fenton-like process using iron nano oxides for pyrene removal from contaminated soils, Iran. J. Health Environ. 7 (2014) 301–314.

[22] R.R. Kalantary, M. Rahmatinia, M. Moradi, Data on modeling of UV/Na2S2O8/FeS2 process in amoxicillin removal using Box-Behnken methodology, Data Brief 19 (2018) 1810–1815.

[23] M.S. Reddy, B. Naresh, T. Leela, M. Prashanthi, N.C. Madhusudhan, G. Dhanasri, Biodegradation of phenanthrene with biosurfactant production by a new strain of Brevibacillus sp, J. Bioresour. Technol. 101 (2010) 7980–7993.

[24] Y. Ng, B. Sen, M.A. Gupta Hashim, Stability and performance enhancements of Electrokinetic-Fenton soil remediation, Rev. Environ. Sci. Biotechnol. 13 (2014) 251–263.