

DEGRADATION OF PHENANTHRENE AND NAPHTHALENE WITH THE USE OF POTASSIUM PERMANGANATE

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ABSTRACT

The aim of this contribution is study of potassium permanganate degradation of selected PAH's. Naphthalene and phenanthrene were used as model pollutants. Degradation of these substances takes place in solid matrices - in soil samples. Determination of these substances was performed by high performance liquid chromatography.

KEY WORDS

degradation, liquid chromatography, soil

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are hydrocarbons that contain at least two fused benzene rings in linear, angular or cluster arrangements. PAHs in the molecular weight range between naphthalene (128.16) and coronene (300.36) are of environmental concern. Many PAHs are stable and persistent in the environment and toxic. PAHs are common byproduct formed either by thermal alteration of buried organic matter (petrogenic) or by incomplete combustion of organic matter (pyrogenic). Extensive use of fossil fuels and biomass burning are the major sources of anthropogenic PAHs in the environment.

Major sources of petrogenic PAHs also include crude oil and its refined products, coal and oil shale. Petrogenic PAHs are derived from uncombusted petroleum products and contain relatively low molecular weight PAHs with on to three rings. They are characterized by homologous families of related PAHs such as, naphthalene, fluorenes, phenanthrenes, dibenzothiophenes and chrysenes [1, 2]. Pyrogenic PAHs are generated by the combustion of fossil fuels and organic matter [3, 4]. However, the major sources of PAHs to the environment are industrial activities including coal coking, production of carbon black, creosote and coal tar, petroleum refining, synthetic fuel production from coal, waste incineration and use of internal combustion engines.

Oxidation reaction can be utilized to remediate soils contaminated with PAHs. Different types of oxidants have been investigated ranging from the more commonly studied Fenton's reagent and ozone to less common oxidants such as peroxy-acid, potassium permanganate, hydrogen peroxide and activated sodium persulphate [5, 6].

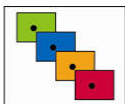
Experimental

Model pollutants: phenanthrene, naphthalene
Sample of soil: albic luvisoil
Solvent: methanol
Mobile phase: methanol:acetonitril - 75:25
Determination: HPLC chromatography with UV detector (Hitachi)
Degradation: exposure to potassium permanganate 10, 20, 30 min

Contaminated soil sample was placed in a beaker (2 g). Sample was added to a solution of potassium permanganate. This mixture was allowed to operate 10, 20 and 30 minutes. Ongoing chemical reactions were stopped by addition of sodium sulfite in the mixture. Horizontal shaker extraction of samples was done (60 minutes). After that was used HPLC chromatography.

Results and discussion

The graphical representation of phenanthrene extraction before and after KMnO_4 degradation is shown on fig. 1. It can be seen that the effect of potassium permanganate has occurred after 10 minutes of action. With increasing time of exposure, the amount of phenanthrene in the sample is reduced. But the most significant reduction was already after ten minutes of



KMnO₄ exposure. Phenanthrene concentration in the sample cannot be calculated because the calibration curve was not constructed for a low concentration of phenanthrene.

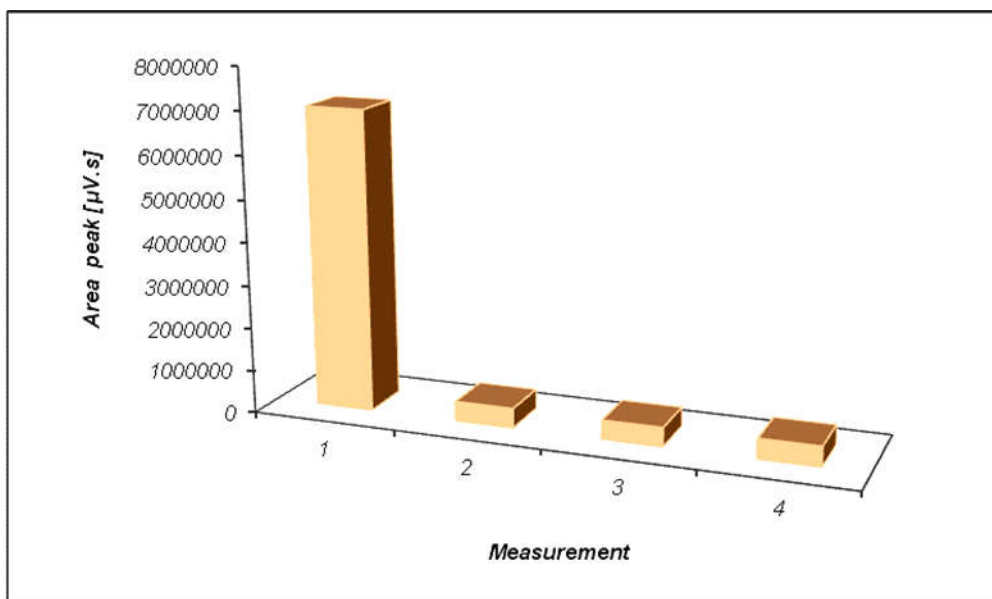


Figure 1 Degradation of phenanthrene by potassium permanganate – horizontal shaker extraction (1- phenanthrene before KMnO₄ degradation, 2 – 10 min, 3- 20 min, 4- 30 min)

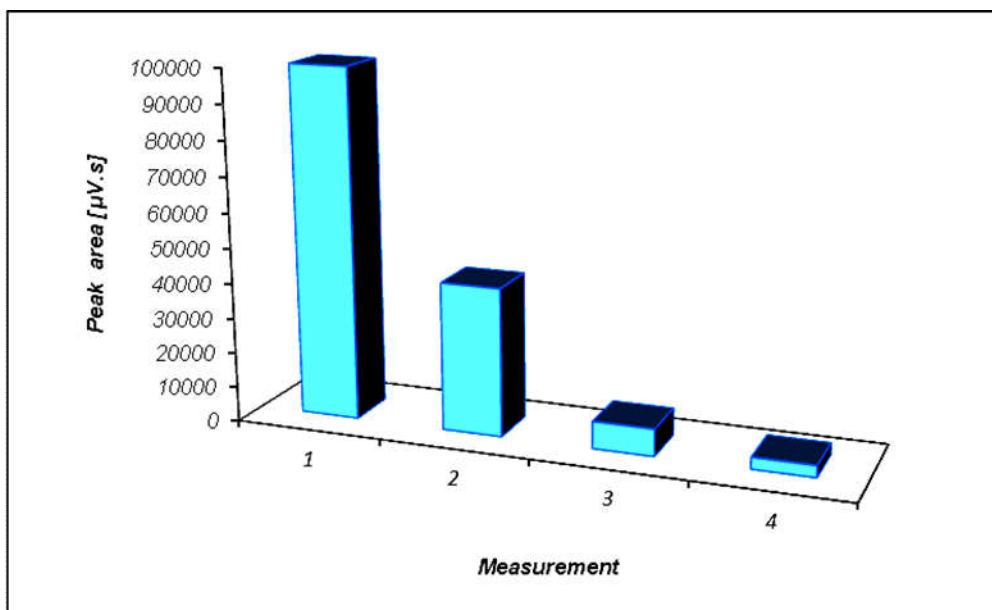
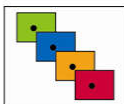


Figure 2 Degradation of naphthalene by potassium permanganate – horizontal shaker extraction (1- phenanthrene before KMnO₄ degradation, 2 – 10 min, 3- 20 min, 4- 30 min)

Degradation of naphthalene was carried out similarly as degradation of phenanthrene. On fig. 2 we can see graphical representation of naphthalene extraction before and after potassium permanganate degradation. In this case, the amount of naphthalene is significantly reduced after potassium permanganate degradation by horizontal shaker extraction. After 10 minutes exposure to KMnO₄ the concentration of naphthalene in the sample significantly decreased.

Conclusion

The present contribution is devoted to study the degradation of selected organic pollutants progressive methods. As the organic pollutants were selected polycyclic aromatic hydrocarbons (PAHs). PAHs are currently the most watched groups of



organic pollutants in the environment. The practical part of this work was study of PAH degradation progressive methods. It can be stated that its potassium permanganate oxidant capabilities significantly reduce the concentration of selected pollutants in contaminated soil samples. Based on these results, we can confirm that the time of exposure was an important factor in the removal efficiency of selected PAHs. Even the shortest exposure to potassium permanganate significantly decreases the concentration of selected pollutant in soil samples. With increasing exposure time oxidant concentration in soil samples has decreased. Differences, however, have not been significant. It can be concluded that the use of potassium permanganate is a suitable method of reducing soil-PAH. We advise to test different methods of progressive degradation, such as ozone, and then compare the efficiency of degradation.

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REFERENCES

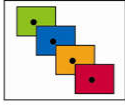
- [1] HARVEY, R.G., Polycyclic Aromatic Hydrocarbons. 1997. Wiley-VCH, Inc., New York, p. 667
- [2] BAEK, S.O., FIELD, R.A., GOLDSTONE, M.E., KIRK, P.W., LESTER, J.N., PERRY, R., A review of atmospheric polycyclic aromatic hydrocarbons: sources, fate and behavior. 1991, *Water, Air and Soil Pollution* 60, 279-300
- [3] MILLER, J.S., OLEJNIK, D., Ozonation of polycyclic aromatic hydrocarbons in water solution, *Ozone Sci. Eng.* 26, 2004, pp. 453-464
- [4] RUEDA-MÁRQUEZ, J.J., MARINA G. PINTADO-HERRERA, M.L. MARTÍN-DÍAZ, ACEVEDO-MERINO, A., MANZANO, M.A., Combined AOPs for potential wastewater reuse or safe discharge based on multi-barrier treatment (microfiltration-H₂O₂/UV-catalytic wet peroxide oxidation), *Chemical Engineering Journal*, Volume 270, 2015, pp. 80-90
- [5] ZEMENG YANG, YUEPENG MA, YING LIU, QUNSHENG LI, ZHIYONG ZHOU, ZHONGQI REN, Degradation of organic pollutants in near-neutral pH solution by Fe-C micro-electrolysis system, *Chemical Engineering Journal*, Volume 315, 2017, pp. 403-414
- [6] MASCOLO, G., CIANNARELLA, R., BALEST, L., LOPEZ, A., Effectiveness of UV-based advanced oxidation processes for the remediation of hydrocarbon pollution in the groundwater: A laboratory investigation, *Journal of Hazardous Materials*, Volume 152, Issue 3, 2008, pp. 1138-1145

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