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REMOVAL OF PHENOL FROM WASTEWATER BY USING LOW-COST CATALYST FROM METAL PRODUCTION

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ABSTRACT

Utilization of AOPs (Advanced oxidation processes) as an emerging technology for removing of pollutants from wastewater is developed. In this paper, UV photodegradation was used for removing of phenol from wastewater. As a source of UV radiation medium pressure mercury lamp with output 400W was used. The influence of low-cost catalysts on this process was also monitored. Wastes from metal production, red mud and black nickel mud, were used as catalysts.

KEY WORDS

Phenol, UV photodegradation, red mud, black nickel mud

INTRODUCTION

The main usage if phenol is as a disinfectant and for cleaning. For its toxical properties is the usage of phenol limited and it is less use as a solvent. It is also used in chemical industry, especially for production of resin and epoxide resins (1). Another way of using phenol is for production of alkyphenols, cresols, xylenes, aniline, as a substance in pesticides, explosives, as a compound of paintings, in a textile manufacture, in a processing of oil and coal. Phenol could be also part of emissions of exhaust gases (2).

On the base of toxicity and carcinogenity of some phenol compounds according to US EPA phenol was proposed to position of 11 from 129 priority monitored chemical compounds in the environment (3).

According to IARC phenol is not proven carcinogen to animal or human. It is clasiffied as mutagene of class 3 and it is proven as a genetic toxicant in animal studies (rat, mouse)

Phenol is not prevent genetic toxicant for animal (mouse, rat) (4).

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MATERIALS

In this paper the influence of catalyst is monitored. Catalysts used for phenol removal:
Red mud – In Slovakia red mud was produced by aluminium plant in Žiar nad Hronom by Bayer process. Red mud is a strongly alkalic (it has high value of pH) as a result of high concentration of NaOH in leaching that cause corrosivity of this waste (5).

Considering their properties- corrosivity, ecotoxicity and leachability red mud is clasiffied as a hazardous waste.

According to US EPA, neutralized red mud because of its large specific surface area has wide usage as an adsorbent and coagulant in the remediation of waters in agriculture, but also in the technology of wastewater cleaning and in chemical industry (5).

Red mud contains Fe_2O_3 (31.80 wt. %), TiO_2 (22.60 wt. %), Al_2O_3 (20.10 wt. %), SiO_2 (6.10 wt. %), CaO (4.78 wt. %), Na_2O (4.70 wt. %), MgO (0.20 wt. %), K_2O (0.03 wt. %) (6).

Fig. 1 *Red mud*

Black nickel mud – Black nickel mud is a waste from nickel and cobalt production. For nickel production hydrometalurgical processes are used (7). Danger point of view is polymetallic dust which spreads into the environment. Despite the high value of oxides of iron (95 %) black nickel mud cannot be used for iron production because of a great content of chromium (approx. 3 %). Neutralized black nickel mud has (as red mud) large specific surface area and is widely use as an adsorbent and coagulant in the remediation of waters in agriculture and also in the technology of wastewater cleaning and in chemical industry. [8, 9]. Black nickel mud contains Fe_2O_3 (38.50 wt. %), FeO (25.63 wt. %), SiO_2 (17.57 wt. %), Al_2O_3 (4.99 wt. %), Cr_2O_3 (3.31 wt. %), Mo (3.19 wt. %), CaO (3.20 wt. %), MnO (0.52 wt. %), C (0.50 wt. %), Ni (0.24 wt. %), Na_2O (0.23 wt. %), TiO_2 (0.17 wt. %) and others (< 0.01 wt. %) (7).

Fig. 2 *Black nickel mud*

SAMPLE PREPARATION

Glass wool surface is covered by red or blach nickel mud and it is annealed in muffle furnace (at 300˚C) in order to reach the best available value for fixation of adsorbent, for removing possible organic contamination of adsorbent and by heat the particle of adsorbent are crushed into fiber so it also increase adsorption capacity of adsorbent. These layers of glass wool contained catalysts were put into UV photoreactor to increase efficiency of phenol removal. Influence of catalysts is monitored.

Fig. 3 *Red mud (1 g) annealed on the glass wool surface (20 x 20 cm)*

Fig. 4 *Black nickel mud (1 g) annealed on the glass wool surface (20 x 20 cm)*

METHOD FOR PHENOL REMOVAL

For removing of phenol from wastewater UV photodegradation is used. It was used itself and also with alternative adsorbents.

UV Photodegradation is a process where UV light is used to irradiate the sample to remove contaminants. The contaminant compound absorbs the UV light and undergoes degradation from its excited state. There is a high efficiency of this type of UV photoreactor because the lamp is surrounded by a solution analyzed. In this paper the source of UV light is medium pressure mercury lamp (MP) with output 400 W (Fig. 5). UV light is defined as the electromagnetic radiation having wavelengths between 10 and 400 nm. This type of UV lamp radiates predominantly UV light at 365 – 366 nm with smaller amounths at 265, 297, 303, 313 and 334 nm.

Fig. 5 *Medium pressure mercury lamp with output 400 W*

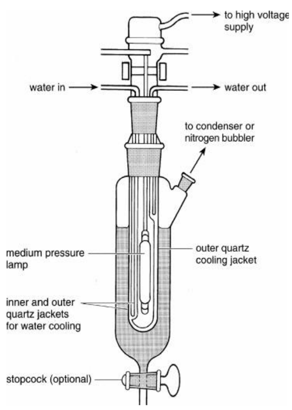

Fig. 6 *UV reactor scheme*

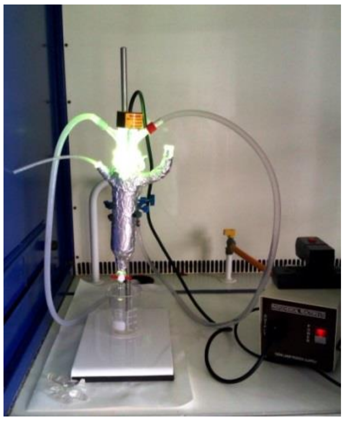

Fig. 7 *UV reactor*

RESULTS

Concentration of phenol was monitored by gas chromatography – mass spectroscopy. GC-MS was carried out using an Agilent 5975C Gas Chromatograph equipped with a capillary column (30 m x 0.250 mm internal diameter) with film 0.25 μm and a He mobile phase. Abundance of detector in phenol sample prepared (with concentration of phenol 10^{-3} mol.dm^{-3}) is 1 324 240.

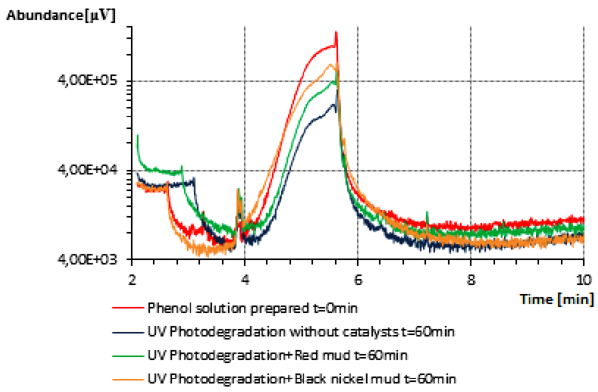

Fig. 8 *Photodegradation of phenol in time 60 min. (400 W lamp)*

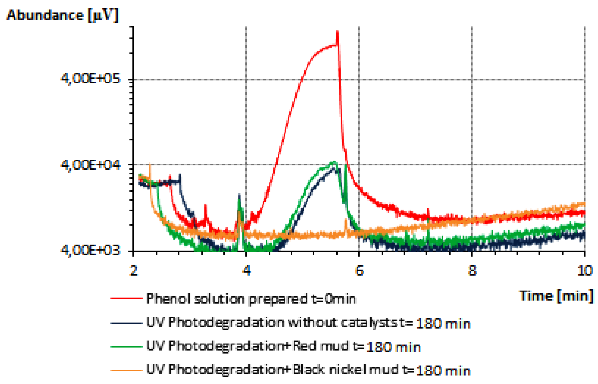

Fig. 9 *Photodegradation of phenol in time 180 min. (400 W lamp)*

Efficiency of phenol removal is calculated by Eq. 1, where A_0 is abundance of detector for prepared phenol sample (t_0) and A_t is abundance of phenol sample in time 60 min and 180 min. (of UV light absorbtion).

$$\eta_t = \frac{A_0 - A_t}{A_0} \times 100\,[\%] \qquad \text{[Eq. 1]}$$

EFFICIENCY OF PHENOL REMOVAL FROM WATER SOLUTION WITH THE USE OF CATALYST IN TIME t = 60 min. and t = 180 min.

Table 1

	Abundance [μV]	**Efficiency [%]**
Phenol solution prepared t = 0min	1 324 240	-
UV Photodegradation without catalysts t = 60 min	293 503	77.83
UV Photodegradation + Red mud t = 60 min	475 868	64.06
UV Photodegradation + Black nickel mud t = 60 min	555 360	58.06
UV Photodegradation without catalysts t = 180 min	21 890	98.34
UV Photodegradation + Red mud t = 180 min	32 653	97.53
UV Photodegradation + Black nickel mud t = 180 min	6 176	99.53

CONCLUSION

As it is showed in Tab. 1 efficiency of phenol removal in time t = 60min is not sufficient. An impact of adsorbents on a process is minimal. The highest value for phenol removal efficiency is seen by using UV photodegradation process without using any catalyst (77.83 %). Minimal impact on process in time t = 60 min. has black nickel mud (58.06 %).

On the contrary, after 180 min. of irradiation the most significant impact on phenol removal has black nickel mud (99.53 %). The smallest impact on process in time t = 180min has red mud as a catalyst (97.53 %).

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