EFFECT OF NANODIAMONDS ON MODEL AZO-DETOXIFICATION PROCESS APPLIED IN THE CRITICAL TECHNOLOGICAL SITUATIONS

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Abstract


The nanodiamonds (ND) are product of nanotechnology, with potential to be used in the biotechnologies as well as in ecobiotechnologies. In the present work, the effect of ND on the technological parameters of azo-detoxification process has been studied. The model wastewater treatment process in two sand lab scale biofilters in semi continuous regime of functioning and model wastewater with increasing concentration of amaranth has been realized: biofilter with ND added in the early phase – 266 h (BEPh) and biofilter with ND added in late phase of the process – 485 h (BLPh). The investigated parameters were efficiency and rate of amaranth removal, COD (Chemical Oxygen Demand) and TOC (Total Organic Carbon). The obtained results showed that ND added in early phase stronger influenced amaranth removal – increased with 4% efficiency of the detoxification, with 90% the rate of transformation and with 15% decreased of COD of the effluent. In the same time the adding of ND at the late phase increased weaker the parameters of the amaranth detoxification. The results showed that the biofilms, functioning in early phase of detoxification were more reactive to the positive modulation effect of ND. The future investigations will be directed to the elucidation of the probable mechanisms of ND effect of the amaranth removing biofilms.

Key words: nanodiamonds, azo-detoxification process, sand biofilters.

Introduction

Azo-dyes represent the largest class of dyes applied in textile processing (Pandey et al., 2007). Their breakdown products are toxic and mutagenic to aquatic life and thus should be removed from the wastewater of the textile factories (van der Zee and Villaverde, 2005). It is extremely difficult for wastewater polluted with azo-dyes to be purified using conventional methods (Grekova-Vasileva and Topalova, 2009). In the literature, some approaches for the improvement of treatment of dye-polluted water have been proposed. Such approaches are the introduction of innovative technologies (Ahmad et al. 2010; Ong et al 2009; Sandhya and Swaminathan, 2006), the application of especially designed adaptation algorithms (Topalova, 2009; Grekova-Vasileva, 2009) and the addition of modulators of the wastewater treatment process (Schneider et al., 2012; Grekova-Vasileva and Topalova, 2007). ND could be used as such modulators (Schneider et al., 2012) with potential in the regulation and control of activity of different biological systems, especially biofilms and activated sludge, that have to be quickly adapted or stimulated to realize the detoxification water treatment technologies.

The aim of this study is to explore the modulating effect of ND on two-phase model azo-detoxification process.

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Materials and Methods

Experimental design: In this study, azo-detoxification process with model xenobiotic (azo-dye Amaranth) has been simulated. The process showed characteristics of biphasic process with two critical periods from technological point of view. This is caused by some facts well known in wastewater treatment - the two stages of biochemical degradation of azo-dyes, the growth of microorganisms according to the classical bacterial growth curve and the xenobiotic impact of the azo-dye. The same effect has been shown in other our articles (for example Schneider et al., 2012). Three types of lab-scale sand biofilters have been constructed: biofilter in which ND have been added in the early critical period BEPh (0–365 hour), biofilter in which ND have been added in the late critical period BLPh (365–623 hour) of the decolorization process and control biofilter. A specialized adaptation algorithm with stepwise rising of inflow concentration of Amaranth from 5 up to 55 mg/l has been applied. The experimental design and the parameters of the detoxification process are shown on the Figure 1. All analyses have been made in threefold repetition for the three biofilters, which are unique systems that cannot be repeated.

Biological system: AS from WWTP of Sofia city was used as inoculation material.

Bioreactors: 0,5L plastic reactors connected with peristaltic pumps. The peristaltic pumps have ensured constant flow in the biofilter.

Synthetic wastewater, Quartz sand, Azo-dye, Nanodiamonds and Immobilization procedure have been described in details in Schneider et al., 2012.

Amaranth concentration: Amaranth concentration has been determined spectrophotometrically (Utraspec3000, PharmaciaBiotech), λ = 520 nm; COD: Potassium bichromate method was used (APHA); TOC: “Shimadzu” TOC-VCPN analyzer was used.

Results and Discussion

The efficiency of xenobiotic removal from the wastewater is complex parameter since it includes not only the azo-dye degraded by the microorganisms, but also the one adsorbed and absorbed by the matrix of biofilm, by the microbial cells and by the sand particles. Nevertheless the efficiency of xenobiotic removal is maybe the most important parameter from technological point of view.

The model azo-detoxification process has shown characteristics of biphasic process. The first phase was from 0 up to 365 hour. The ND have been applied in 269 hour. The characteristics of this phase was logarithmic growth and the adaptation of microorganisms, connected with the rising capability of the biofilm to remove Amaranth (Figure 2a). The second (late) period lasted from 365 hour up to 623 hour. The main characteristic of this period was the destabilization of processes, because the concentration of Amaranth was close to the critical one and because of the biofilm damaging (Figure 2b).

The stabilizing effect of ND for both BEPh and BLPh continued from the addition of the nano-particles (269 hour for BEPh and 482 hour for BLPh) until 555 hour when the threshold concentration of the xenobiotic (55 mg/l) has been applied and the weakening of the impact of ND has been observed (Figures 2 and 3). The stabilizing effect of ND consists of the lack of fluctuation in the dynamics of the detoxification process after the point of addition of the nanoparticles in the two observed critical situations – the formation of the biofilm in the presence of rising concentration of Amaranth and the destabilization processes in the biofilm, caused by the toxic effect of the azo-dye when applied in higher concentrations.

The data of the key kinetic parameters (Table 1) showed that ND has had effect on almost all parameters. The flow rate has been increased in the period after the addition of ND

![Fig. 1. Experimental design](image-url)
in both biofilters. The most probable reason for this was the inhibition effect of the high xenobiotic concentration – the biofilm growth was suppressed and because of this, the space between sand particles became larger. Simultaneously it has been achieved an increase of the efficiency of Amaranth removal and higher rate of the azo-dye transformation (Table 1). In effluent the COD values have been also reduced (Table 1).

### Conclusions

The ND-stimulation in the early or in the late phase of sand biofilters performance accelerated the Amaranth removal and influenced positively all technological parameters. This effect was better expressed in early phase of stimulation.

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References


