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SILVER NANOPARTICLES INCORPORATED IN PHYLLOSILICATES – SYNTHESIS, CHARACTERIZATION AND APPLICATIONS

Diana-Carmen Mirila[1], Dumitra Raducanu[2], Platon Nicoleta[1], Mohamed Amine Didi[3], Abdelkrim Azzouz[4], Nistor Denisa[1]*, Jinescu Gheorghita[5]

[1]„Vasile Alecsandri" University of Bacau, Faculty of Chemical and Food Engineering, Catalysis and microporous materials laboratory, 157 Marasesti Str., Bacau – 600115, miriladiana@ub.ro, dnistor@ub.ro, Romania
[2]„Vasile Alecsandri" University of Bacau, Faculty of Sciences, 157 Marasesti Str., Bacau - 6000115, Romania
[3]University Abou Bekr Belkaid-Tlemcen, Department of Chemistry, Abi Ayed Abdelkrim FG Pasteur BP 119 13000, Tlemcen, Algeria
[4]University of Quebec at Montreal, Department of Chemistry, Nanoqam, Montreal, QC H3C3P8, Canada
[5]Polytechnic University of Bucharest, Faculty of Applied Chemistry and Materials Science, Department of Chemical Engineering, Splaiul Independentei 313 A, sector 6, Bucharest, Romania

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Introduction

Wastewaters contain a wide variety of organic compounds, such as organochlorine pesticides, organophosphorus peptides, chlorophenols, fuels, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, dyes, among others. In the last decades, harmful organic compounds such as those have been reversed in the environment. AOPs (Advanced Oxidation Processes) are essentially physico-chemical technologies based on the in situ generation of oxidizing species that have a high reactivity to organic and inorganic matter. The OH radical is capable of reacting instantly and non-selectively with both organic and inorganic compounds at reaction rates in the order of 10^7 and 10^{10} L mol^{-1} s^{-1}, and can decompose organic compounds by extracting hydrogen from certain functional groups, direct electron transfer or radical-radical interactions. Among all oxidative techniques, the most effective and eco-friendly technique are represented by catalytic ozonation. This process involves O_3 and a homogeneous or heterogeneous catalyst. The aluminosilicate family includes a wide variety of amorphous and crystalline philosophies, such as clays, clay minerals and tectosilicates (e.g., zeolites). The common feature of all these structures is the occurrence of permanent negative charges resulting from the replacement of tetrahedra [SiO_4] with anions [AlO_4]. These charges can be offset by cations that usually belong to alkali and alkaline earth metals. Aluminosilicates are solid acids that have been used as catalysts in many chemical processes.

Materials and methods

Silver nitrate ($AgNO_3$), sodium chloride (NaCl), sodium tetrahydroborate ($NaBH_4$), ethanol (C_2H_5OH), Malachite Green (MG, $C_{23}H_{25}N_2$, MW: 364.911 $g.mol^{-1}$), Tartrazine (AY23, $C_{16}H_9N_4Na_3O_9S_2$, MW: 534.3 $g.mol^{-1}$) Levenhuk immersion oil, Gram Staining kit for microscopy, were obtained from Sigma-Aldrich (USA).

Bentonite (BN) were purchased from Fluka. Ceftaroline fosamil CPS 30 ($C_{22}H_{21}N_8O_8PS_4$) and ciprofloxacin CIP 5 ($C_{17}H_{18}FN_3O_3$) antibiotics were obtained from Oxoid (USA). *Escherichia coli* ATCC 25922 strains were purchased from Thermo Scientific (USA). MG and AY23 were used as probe molecules in aqueous 10^{-5} M solutions. Double distilled water was used throughout this work.
A facile, eco-friendly and cost-effective method involving an aluminosilicate coated with silver was developed to prepare a microporous material BN-Ag^0 core shell with high catalytic and bactericidal / bacteriostatic activities against newly isolated bacterium from sewage sludge, named *ISO SS*. The catalytic activity of this nanomaterial was tested in catalytic ozonation processes targeting a total mineralization of Malachite Green and Tartrazine dyes.

Results and conclusions

In the case of adsorption as well as non-catalytic or catalytic ozonation of the azo dye Tartrazine solution, the mineralization did not take place due to the appearance of the hyperchromic effect, providing clear confirmation of the nonoccurrence of dye adsorption / mineralization. The results were supported by an increase in the intensity over time of the absorbance of the dye solution (5 x 10^{-5}M) at 425 nm on BN and BN-Ag^0, and was also reflected by a visible progressive increase in coloration.
The best yield in the degradation of dye MG was 86.45% was obtained by using 2.5 mg/20 mL of Bn-Ag^0 and 0.5 g/h of ozone. Compared with the simple ozonation and catalytic ozonation with BN, the introduction of the BN-Ag^0 greatly reduce the duration of the process, from 1 hour and 50 minutes with a yield of 97% in just 5 minutes with a yield of 86.45%.
In parallel to the catalytic activity against MG and AY23, the antibacterial activity of BN-Ag^0 using different amounts (from 10 to 30 mg) was evaluated for *ISO SS*. An inhibition zone was observed and bacteria don't remain on the entire surface, showing the presence of an 4 mm of inhibition zone with a diffusion process around the sample. The diameter of the inhibition zone against *ISO SS* using clay embedded with Ag^0 was found to vary according to the amount of the material, since *ISO SS* was less affected when the amount of BN-Ag^0 nanomaterial was lower. The nature of silver ions may be one of the possible reansons for this.