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Preparation of activated carbon based environmentally functional materials and their adsorption and photodegradation properties

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The utilization of industrial wastes in application of water treatment is an efficient and economical solution for environmental problems. The sorption technology is widely applied to water treatment, and the simultaneous adsorption and photocatalytical mineralization of organics by solar light with low-cost materials is very promising energy-saving technology. The removal of organic and inorganic water pollutants by sorbents with multiuptake ability and development of photo-Fenton-like process in oxalate system can be considered as effective applications in water treatment technologies.

This work deals with the preparation of sorbents and photocatalysts for water treatment based on combination of activated carbon with inorganic low-cost materials and wastes.

The main objectives of this study are

-utilization of wastes and enhance of detoxification and biodegradability of industrial effluents;

-preparation of new low-cost effective materials on the basis of different industrial wastes and AC with multifunctional adsorption and photodegradation ability

Chapter 1 is the general introduction and background to this research. The literature review concerned activated carbon (AC) and low-cost inorganic wastes for water treatment, adsorption and photodegradation. The needs, objectives and approach for the research are also discussed.

Chapter 2 deals with preparation of AC from refused paper fuel (RPF) granules (old paper and plastic). The combination of carbon and inorganic ash components lead to formation of highly porous materials consisting of activated carbon and amorphous CaO–Al_2O_3–SiO_2 (CAS). The samples prepared by physical and chemical activation showed multisorption properties for Ni^{2+} (representative of a heavy metal), PO_4^{3-} (representative of a harmful oxyanion) and methylene blue (MB) (representative of an organic dye). The physically activated samples were more suitable for sorption of Ni^{2+} and PO_4^{3-} due to

high ash content. The chemically activated sample showed the highest S_{BET} and sorption capacity for MB.

Chapter 3 describes sorbents prepared from paper sludge by mechanically grinding, calcining and physical activation. The physically activated sample showed highest S_{BET} value. The multiuptake properties are attributed to the presence of amorphous CAS and AC in the sample. The samples with a carbon content of 50–60 mass% are suggested to be optimum for simultaneous uptake of heavy metals (Ni^{2+}), harmful oxyanions (PO_4^{3-}) and organic dyes (MB).

Chapter 4 deals with utilization of different types of Uzbekistan industrial wastes related to CAS materials. The multiuptake properties for Ni^{2+}, PO_4^{3-}, NH_4^+, and MB on Almalyk phosphogypsum (F) and Angren kaolin (K) as well as steel converter sludge (S) and Shurtan spent alumina catalyst (A) were studied. The uptake capacities of the F-K samples increases in following order - $PO_4^{3-} > NH_4^+ >> Ni^{2+}$, while A-S samples showed contrast uptake order - ($Ni^{2+} > NH_4^+ > PO_4^{3-}$). These materials showed slight increasing of pH after the treatments and can be considered as suitable for actual water treatment.

Chapter 5 describes the preparation of microporous and mesoporous materials based on the commercial powder and granular AC and iron oxides. The materials prepared by impregnation with different iron precursors (iron (III) nitrate, chloride, benzohydroxamate, oxalate). The combination of heterogeneous and homogeneous MB photodegradation under UV and solar illumination in presence of oxalic acid (OA) was observed. The MB adsorption in the dark correlated with specific surface areas and pore volumes. Photodegradation depends on metal oxide content, porous properties, pH, OA and MB concentrations. The microporous samples have tendency to desorb MB into solution in contrast of mesoporous samples. The application of prepared materials in cyclic operation is possible, and total MB and OA mineralization under UV-irradiation was observed.

Chapter 6 deals with study of adsorption and photodegradation of MB in aqueous solution and acetaldehyde in gaseous phase using materials prepared from activated carbon fiber felt (ACFT) with Fe_2O_3 and TiO_2. The ACFTs consisted of polyester and microporous AC fibres and as well as polyethylene pulp and mesoporous AC fibres. The ACFTs were impregnated by Fe_2O_3 and TiO_2. The combination of the homogeneous and

heterogeneous MB degradation and the MB desorption effect explain better degradation in aqueous solution by mesoporous samples. The mesoporous samples have better adsorption and heterogeneous photodegradation of gas-phase acetaldehyde (AcH) under UV light irradiation, respectively.

Chapter 7 presents the summary of the research and potential area for the future research and investigations are also suggested in this chapter.

The wastewater sorbents based on activated carbon and different low-cost and waste materials from Japan and Uzbekistan were prepared. New prepared sorbents with multiuptake properties were studied for adsorption of organic and inorganic water pollutants (Ni^{2+}, PO_4^{3-}, NH_4^+ and MB). The materials for simultaneous adsorption and photodecomposition were prepared from different activated carbons impregnated with iron oxides from various precursors. The materials showed high adsorption and photodegradation of organic pollutants due to combination of adsorption, heterogeneous and homogeneous catalysis under UV and solar lights without addition of hydrogen peroxide.