SILICA WITH CHEMICALLY IMMOBILIZED METHYL RED FOR REMOVAL OF DYE POLLUTANTS FROM DILUTED SOLUTIONS

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The use of organic dyes in the textile, printing, leather, paper, pharmaceutical and other industries results in the release of considerable amounts of dye-containing effluents into the environment. Among them azo dyes belong to the most numerous (60–70 % of all dyes) and hazardous class of pollutants. Potential danger for human arises from toxic, carcinogenic, mutagenic, and teratogenic effects of azo dyes and their biotransformation products, aromatic amines. Therefore, development of affordable, effective and simple techniques for removal of azo dyes from wastewaters is of great interest.

Our research was focused on the design of effective silica sorbent for industrial azo dyes removal from wastewaters. For this, silica with chemically immobilized methyl red (MR) moieties (MR-NH_2-MCM-41) was synthesized by base catalyzed sol–gel condensation of tetraethoxysilane and MR-silane as silica source, and quaternary ammonium salt as structure directing agent. The influence of MR-containing groups on mesoporous structure of resulting material was elucidated by low-temperature adsorption-desorption of nitrogen as well as x-ray powder diffraction analysis and compared with corresponding parameters for control silica (NH_2-MCM-41) with surface 3-aminopropyl groups (Table). Composition of surface layer of prepared silica sorbents was established by potentiometric titration of 3-aminopropyl groups (Table).

Table. Structural parameters of MCM-41-type silica materials.

Silica	S, m^2/g	V, cm^3/g	D, nm	[3-aminopropyl groups], mmol/g
NH_2-MCM-41	515	0.91	3.93; 5.09	0.28
MR-NH_2-MCM-41	828	0.72	3.54; 5.29	0.18

Sorption of MR on synthesized silica materials was studied in dependence of acidity of solution and contact time. In accordance with the obtained results, effective removal of MR from diluted aqueous solutions by NH_2-MCM-41 takes place at pH values from 2.5 to 5. Introduction of MR-containing groups in surface layer of silica sorbent causes substantial increase of MR uptake over pH range from 1 to 7. Obviously, in addition to the hydrogen bonding, hydrophobic interactions of adsorbate with MR-NH_2-MCM-41 surface play a key role in sorption. In accordance with the kinetic studies, process of MR sorption on synthesized materials follows the pseudo-second order kinetic model. Analysis of Weber-Morris plots indicates that the intraparticle diffusion is not the only one mechanism controlling the rate of MR sorption removal.

In order to evaluate the influence of chosen synthetic strategy on the affinity of resulting mesoporous materials to the various dye pollutants, comparative sorption of different dyes (MR, alizarin yellow (AY), dimethyl yellow (DMY), methyl orange (MO), m-cresol purple (MCP), alizarin red S (AR), and eriochrome black R (ECB)) on synthesized silicas was studied from phosphate buffer solutions with pH 4.8 (Fig.).

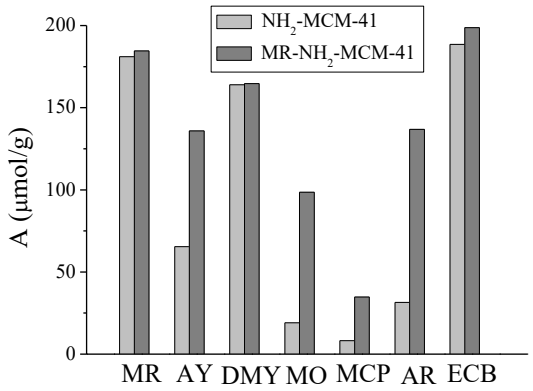

Fig. Removal of dye pollutants by NH_2-MCM-41 (light gray) and MR-NH_2-MCM-41 (dark gray) from phosphate buffer solutions (pH 4.8) with initial concentrations of dyes equal to 0.2 mmol/l.

Obtained results can be useful in creation of new organosilica materials for effective dye pollutants removal from wastewaters.