EVALUATION OF ADSORPTION PERFORMANCE OF PHOSPHATES REMOVAL USING CELL-MG HYBRID ADSORBENT

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ABSTRACT

Due to the high accumulation of nutrients in water (primarily phosphates) because of increased use of fertilizers and plant protection products, it is necessary to apply various techniques for their detection, and then removal. Adsorption is one of the promising techniques to removing them. Magnetite (MG) modified cellulose membrane (Cell-MG), obtained by reaction of 3-aminosilane and subsequently with diethylenetriaminepentaacetic acid dianhydride functionalized waste Cell fibers (Cell-NH_2 and Cell-DTPA, respectively), and amino-modified diatomite was used for phosphate ions removal from water. Cell-MG membrane was structurally and morphologically characterized using SEM and TEM techniques. The influences of operational parameters, i.e. pH, contact time, temperature, and the mass of adsorbent on adsorption and kinetics were studied in a batch system. The calculated capacities of 79.08 mg/g at 45 °C for phosphate ions were obtained from non-linear Langmuir model fitting. The reusability of adsorbent and results from wastewater purification showed that Cell-MG could be used as general-purpose adsorbent. Based on the kinetic studies the adsorption process follow the pseudo second-order model. Thermodynamic parameters showed that the adsorption process is endothermic and spontaneous.

SURFACE MORPHOLOGY ANALYSIS

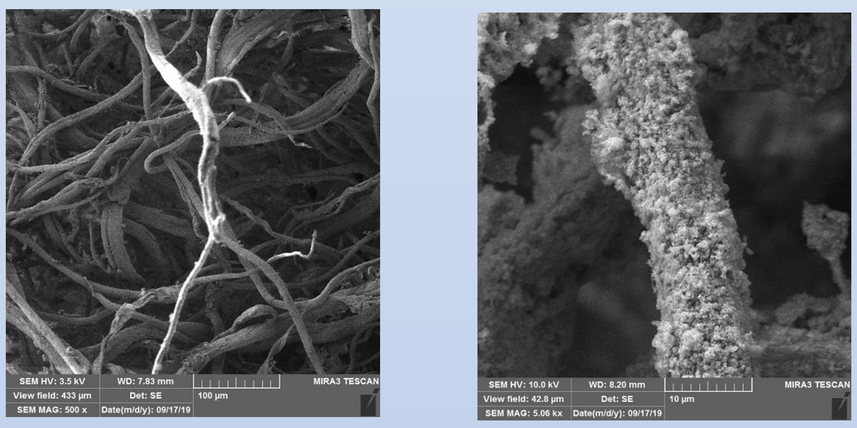

Figure 1. SEM images of Cell based membrane (left) and Cell-MG hybrid membrane (right)

TRANSIENT ELECTROMAGNETIC ANALYSIS

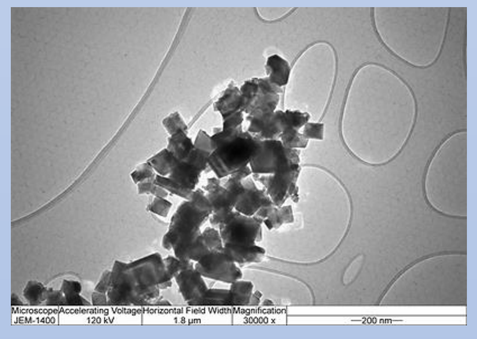

Figure 2. TEM image of Fe_3O_4 particles

THERMODYNAMIC PARAMETERS OF ADSORPTION

Table 3. Calculated Gibbs free energy, enthalpy and entropy for the PO_4^{3-} adsorption on Cell-MG hybrid membrane

Ion	ΔG° (kJ/mol)			ΔH° (kJ/mol)	ΔS° (J/mol K)	R^2
PO_4^{3-}	298 K	308 K	318 K			
	-36.13	-38.11	-40.35	26.72	210.7	0.992

Table 4. Pseudo-first, pseudo-second and second order reaction kinetic parameters for the PO43-adsorption using Cell-MG adsorbent

Ion/order of kinetic law		Pseudo-first	Pseudo-second	Second order
PO_4^{3-}	q_e	51.67	66.44	66.44
	k (k_1, k_2)	0.062	0.003	0.008
	R^2	0.930	0.984	0.934

ADSORPTION KINETICS

Table 1. The results of non-linear fitting using Langmuir isotherm model for PO_4^{3-} adsorption onto Cell-MG hybrid membrane

Ion	Temperature	q_m (mg/g)	K (dm^3/mg)	K_L (dm^3/mol)	R^2
PO_4^{3-}	25 °C	69.51	0.406	38524,623	0.989
	35 °C	71.51	0.546	51903,707	0.996
	45 °C	79.08	0.799	75946,905	0.992

Table 2. Non-linear Freundlich and Dubinin-Radushkevich isotherm parameters for PO_4^{3-} on Cell-MG membrane

	Parameters	25 °C	35 °C	45 °C
Freundlich isotherm	K_F (mg/g) (dm^3/mg)$^{1/n}$	46.21	70.58	126.5
	1/n	1.309	1.313	1.299
	R^2	0.989	0.991	0.994
Dubinin-Radushkevich isotherm	q_m (mg/g)	57.18	65.42	79.66
	K_{ad} (mol^2/KJ^2)	7.420	7.280	7.080
	E_a (KJ/mol)	8.212	8.287	8.401
	R^2	0.898	0.917	0.943

CONCLUSION

Magnetite-synthesized (MG) modified cross-linked carboxy functionalized cellulose membrane showed good efficacy for removing phosphate ions from water. The obtained results indicate that both the properties of phosphate ions and hybrid membrane adsorbent affect the manner and extent of sorbate-surface functionalities interactions. Based on kinetic and thermodynamic studies, it was confirmed that Cell-MG membranes as adsorbents have a high potential. The obtained results and applied methods are in line with the current trend in environmental protection where understanding the molecular interaction helps to design a new adsorbent with better performance.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract Nos. 451-03-9/2021-14/200066; 451-03- 9/2021-14/200023;451-03-9/2021-14/200135; 213-1/21-08-03-2021)