9th International Conference on Sustainable Solid Waste Management,
15-18 June 2022, Corfu, Greece

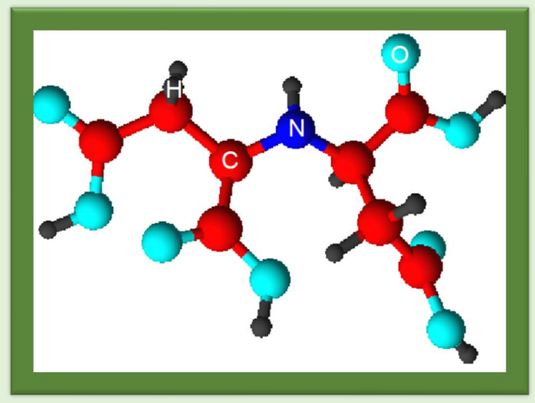
IDHA - biodegradable complexing agent in the adsorption of rare earth elements

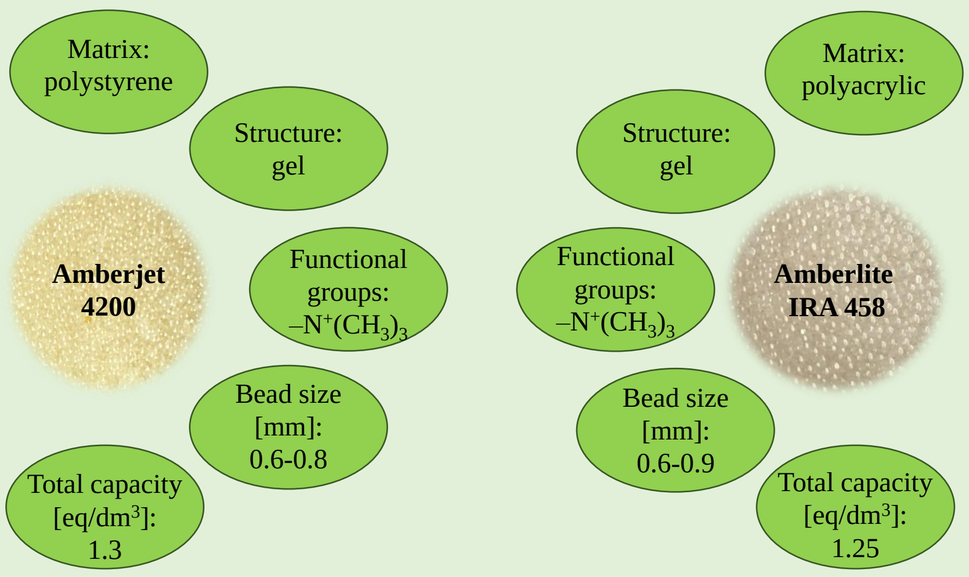
K. BURDZY*, D. KOŁODYŃSKA

Department of Inorganic Chemistry, Institute of Chemical Sciences, Maria Curie-Skłodowska University, M. Curie Skłodowska Sq. 2, 20-031 Lublin, Poland
**e-mail: katarzyna.araucz@poczta.umcs.lublin.pl*

INTRODUCTION

Rare earth elements (REEs) are a group of 17 elements, including scandium, yttrium, and lanthanides. They are considered to be strategic metals being essential for the development of modern technology, so research on new methods of rare earth recovery has developed in recent years. One of them is adsorption, which compared to other known methods has the advantage of reducing solvent consumption and being able to obtain a high purity product. Chelating agents are commonly used in the adsorption process to increase its efficiency. Iminodisuccinic acid (IDHA, N-(1,2-dicarboxyethyl)-D,L-aspartic acid) is a chelating agent from the aminopolycarboxylic acid group. Due to the presence of four carboxyl groups and a nitrogen atom in the molecule, IDHA is called the pentadentate N, O donor ligand. Despite having a structure very similar to that of the well-known ethylenediaminetetraacetic acid (EDTA), IDHA is characterized by high biodegradability. The ability to form complexes with multiple metal ions while being highly biodegradable makes IDHA a potential alternative to poorly biodegradable complexing agents.





METHODOLOGY

The aim of this study was evaluation of the IDHA effect on the adsorption process of La(III) ions on strongly basic anion exchangers with the quaternary ammonium functional groups: Amberjet 4200 and Amberlite IRA 458, as well as optimization of the process conditions by determining the influence of the metal:ligand molar ratio (1:1, 1:2, 1:4), initial solution pH (2-12), phase contact time (1-240 min), initial solution concentration (0.5×10^{-3} M-8.5×10^{-3} M), and temperature (293-333 K). The studies were carried out using the batch method. The concentrations of metal ions were analysed by the inductively coupled plasma optical emission spectrometry using ICP-OES 720-ES (Varian, USA).

RESULTS

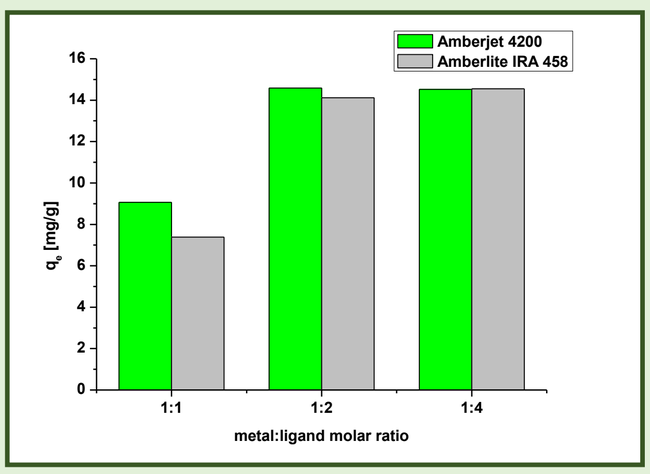


Fig.1. The effect of the metal:ligand molar ratio on the adsorption of La(III) complexes with IDHA on Amberjet 4200 and Amberlite IRA 458.

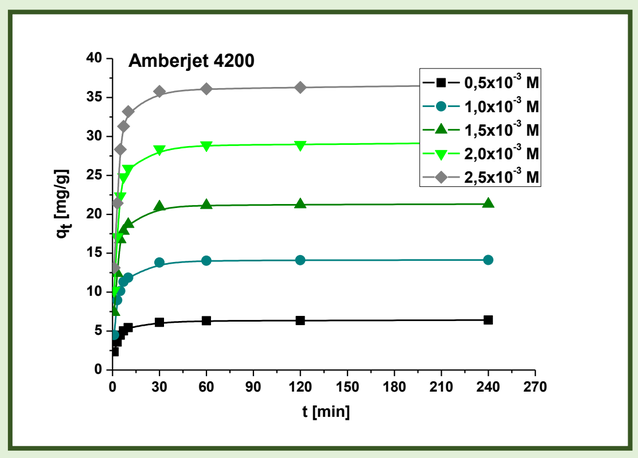


Fig.3. The effect of phase contact time and initial solution concentration on the sorption of La(III) complexes with IDHA on Amberjet 4200.

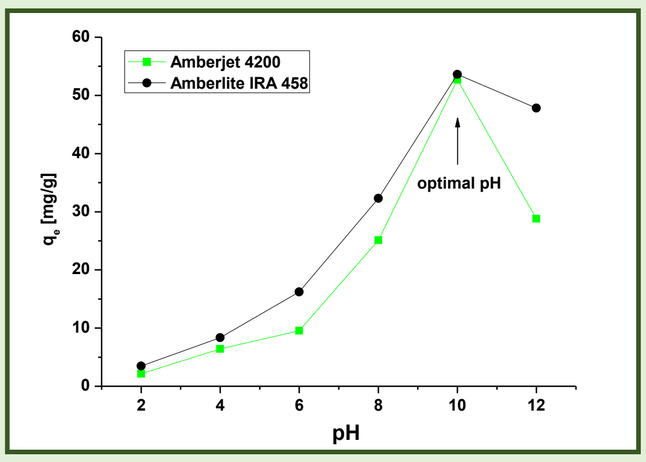


Fig.2. The effect of pH on the sorption of La(III) complexes with IDHA on Amberjet 4200 and Amberlite IRA 458.

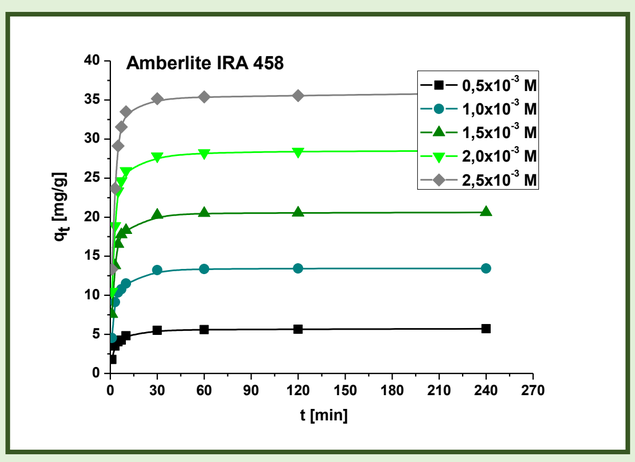


Fig.4. The effect of phase contact time and initial solution concentration on the sorption of La(III) complexes with IDHA on Amberlite IRA 458.

Table 1. The kinetic and adsorption isotherm parameters for the adsorption of La(III) complexes with IDHA on Amberjet 4200 and Amberlite IRA 458.

Models	Parameters	Amberjet 4200	Amberlite IRA 458
	q_{exp} [mg/g]	6.41	5.73
Kinetic models			
Pseudo-First Order	q_1 [mg/g]	6.18	5.50
	k_1 [1/min]	0.280	0.281
	R^2	0.926	0.937
	χ^2	0.149	0.110
Pseudo-Second Order	q_2 [mg/g]	6.49	5.80
	k_2 [g/mg min]	0.0733	0.080
	R^2	**0.991**	**0.995**
	χ^2	**0.019**	**0.009**
Intraparticle Diffusion	k_{i1} [mg/g $min^{1/2}$]	1.65	1.53
	C_1	0.72	0.49
	R^2	0.998	0.925
Adsorption isotherm models			
	q_{exp} [mg/g]	68.87	79.21
Langmuir	q_m [mg/g]	64.71	83.40
	K_L [L/mg]	0.219	0.053
	R^2	**0.958**	**0.985**
	χ^2	**26.617**	**12.802**
Freundlich	K_F [mg/g]	20.63	16.39
	n	4.94	3.62
	R^2	0.911	0.867
	χ^2	56.323	114.558
Temkin	A [L/g]	4.95	0.66
	B [J/mol]	9.08	15.32
	R^2	0.957	0.951
	χ^2	27.430	42.023

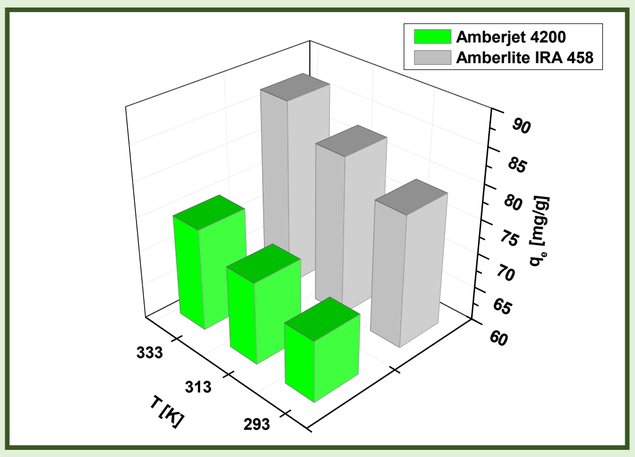


Fig.5. The comparison of the maximum adsorption capacity of adsorbents in relation to the La(III)-IDHA complexes for different temperatures.

CONCLUSIONS

- In the equilibrium state at 293 K, the highest adsorption capacity was achieved for the La(III)-IDHA-Amberlite IRA 458 system (79.21 mg/g). The optimum process conditions are: the metal:ligand molar ratio of 1:2, solution pH of 10, phase contact time of 30 minutes, and temperature of 333 K.
- The process kinetics follows the pseudo-second order kinetic model.
- Based on the adsorption isotherm studies, it was found that the Langmuir model provides the best fit to the experimental data.
- Iminodisuccinic acid exhibits good complexing properties and can be an alternative to the currently used compounds with poor biodegradability.