The iron oxide sorbent modified with lanthanum(III) ions in the context of arsenic removal

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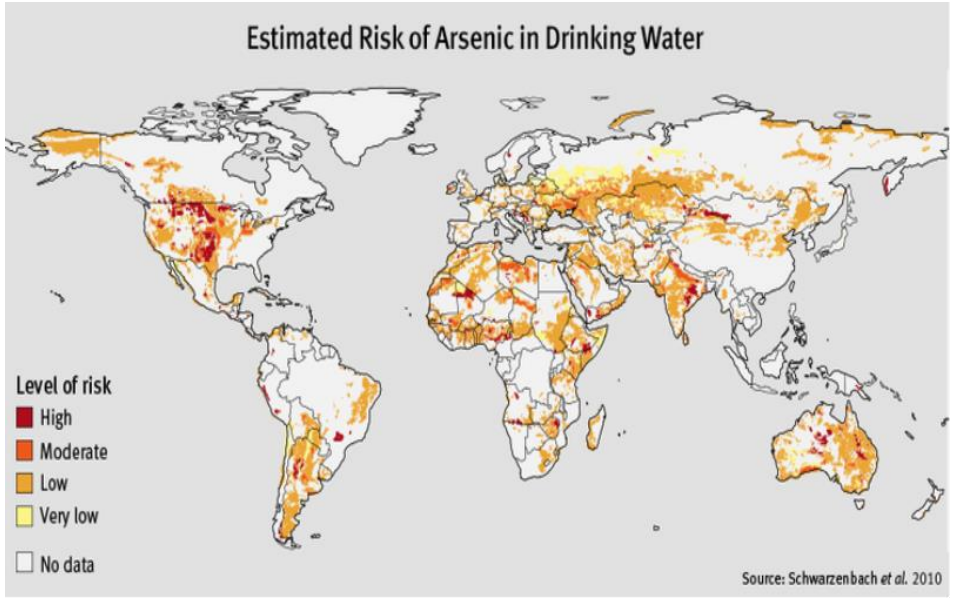
Arsenic contamination of groundwater



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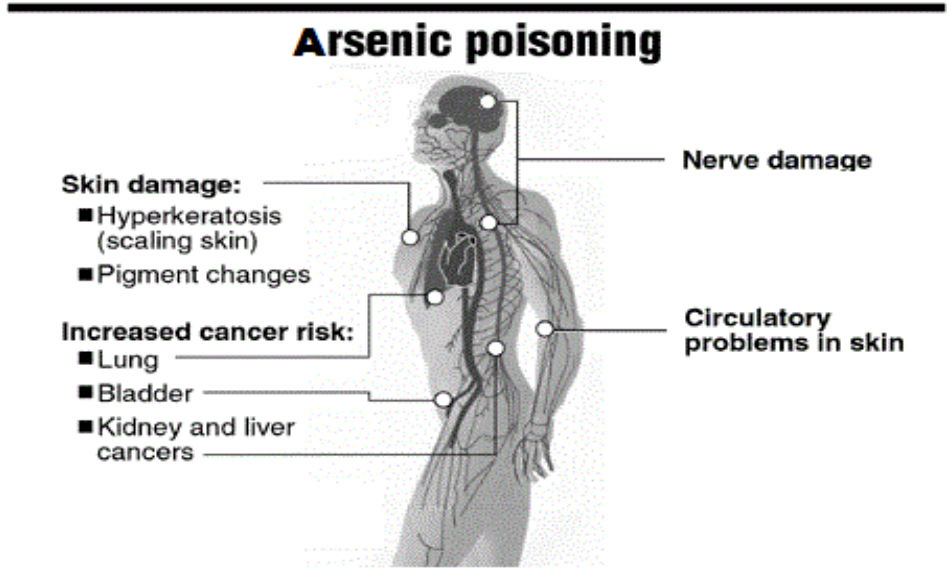
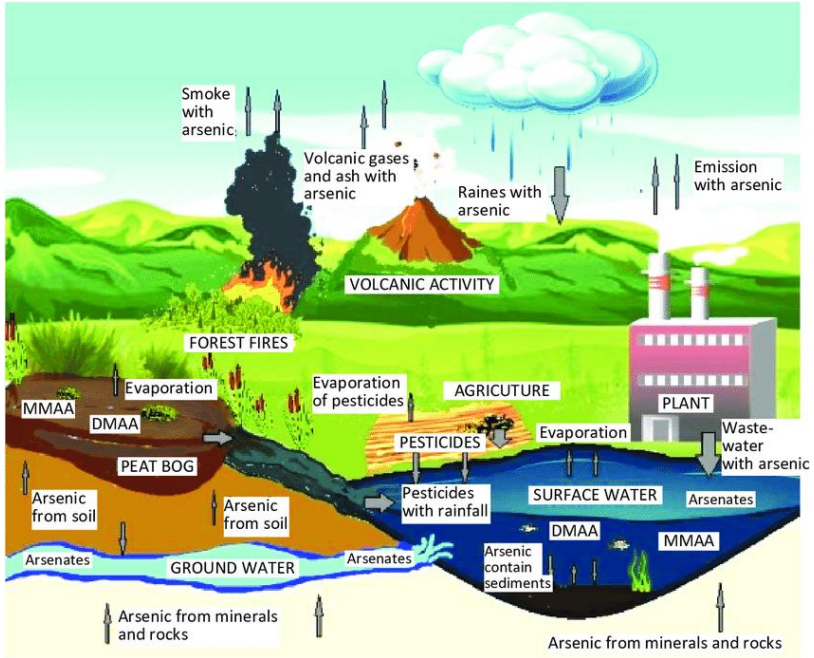
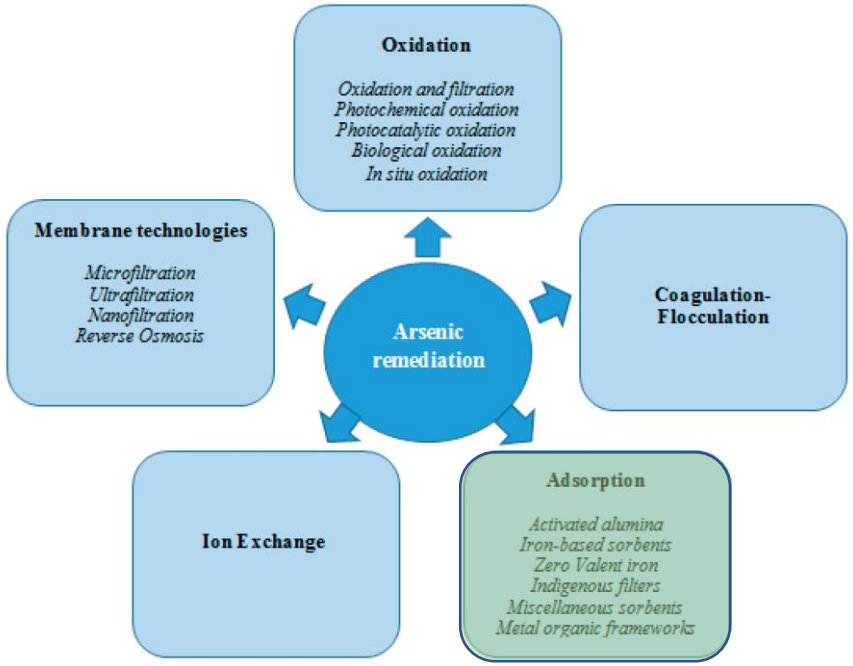
The recommended limit of arsenic concentration in drinkining water (according to the WHO guidelines):

0.01 mg/L





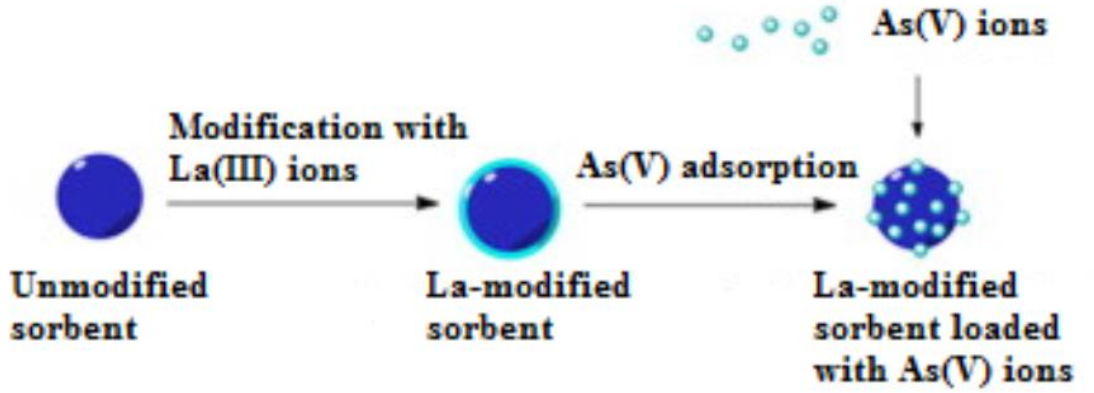


Aims of the study

- ✓ Modification of Arsen X^{np} with La(III) ions and characterization of novel composite material with various techniques

Assuring Arsenic Elimination

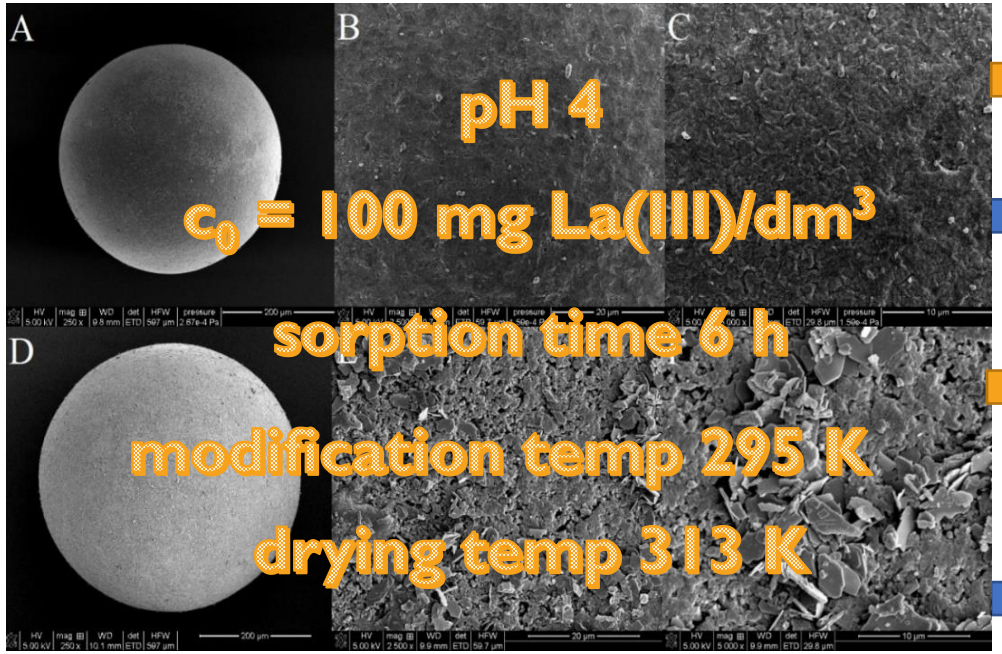
SEM N_2 adsorption/ desorption FTIR



- ✓ Description of the As(V) ions adsorption process including sorption kinetics, equilibrium, effect of pH as well as regeneration.
- ✓ Comparison of sorption properties of the modified material with the unmodified one and evaluation of its application in the industrial process.

Modification of X^{np} with lanthanum(III) ions

SEM analysis

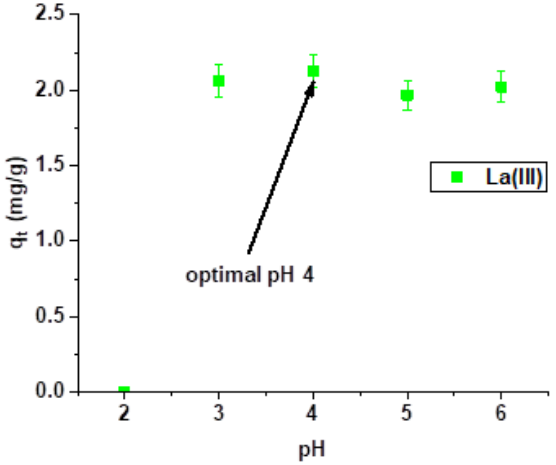


→ smooth surface

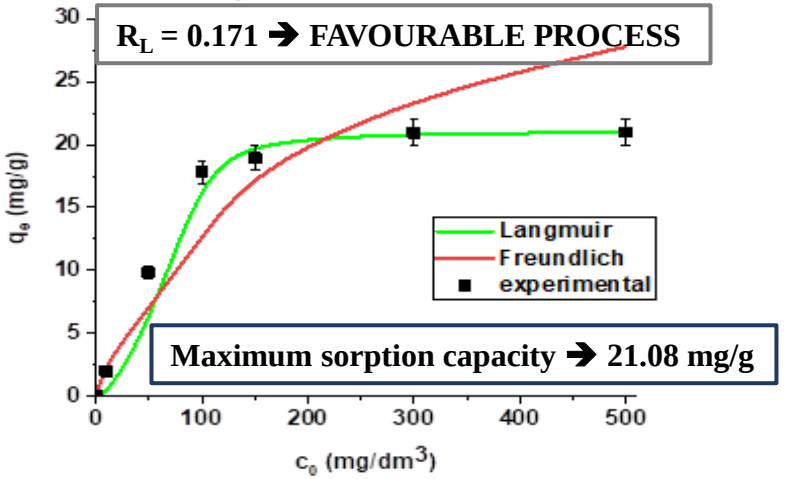
→ X^{np} nanoflakes of several hundred nanometers spread over the surface

→ X^{np}-La(III)

Effect of pH on lanthanum(III) adsorption

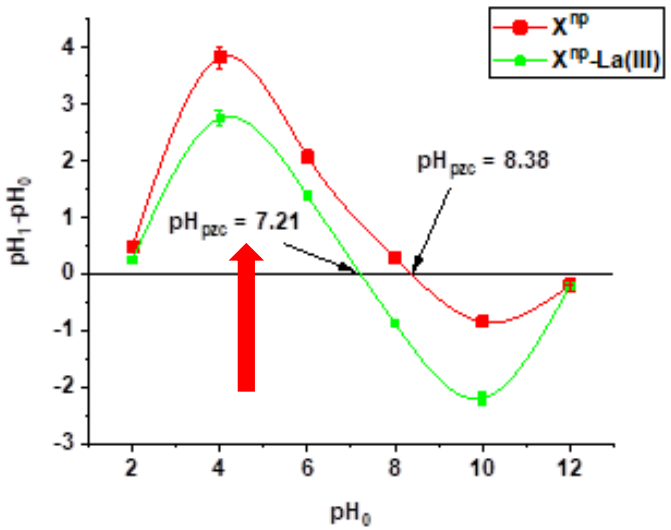


The sorption isotherms of La(III)

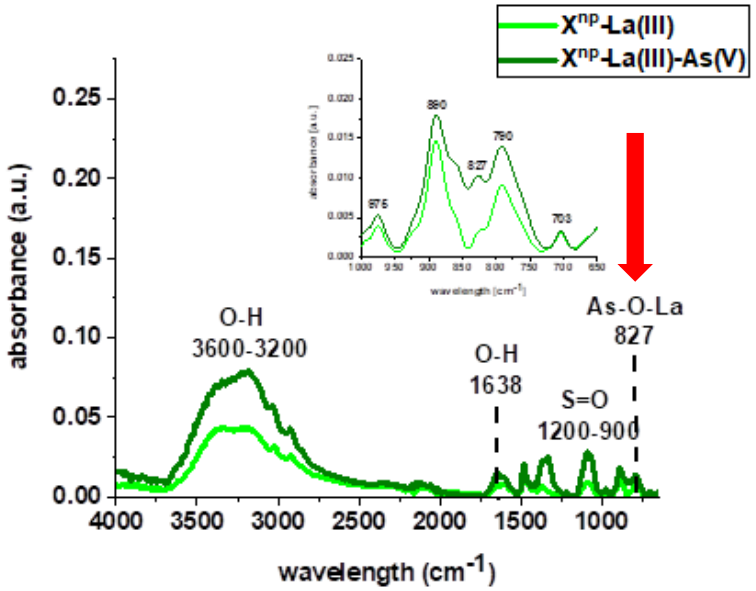


X^{np}-La(III) characterization

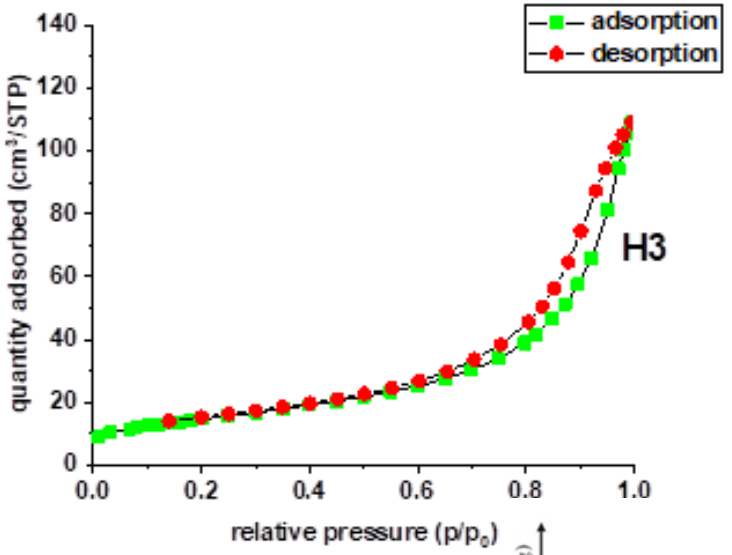
Point of zero charge pH_{pzc}

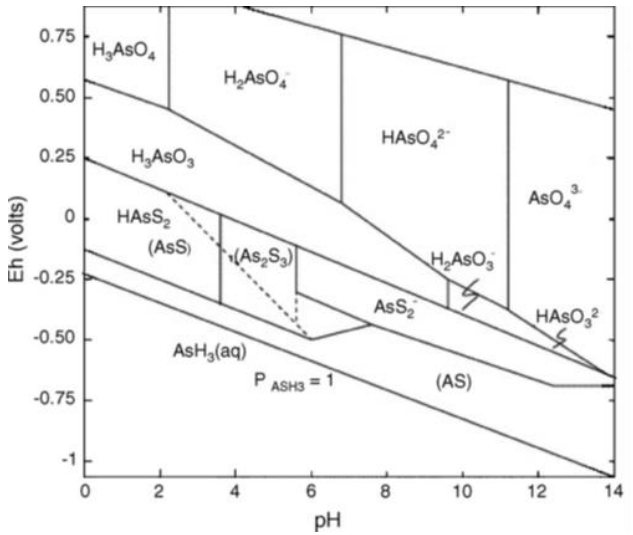


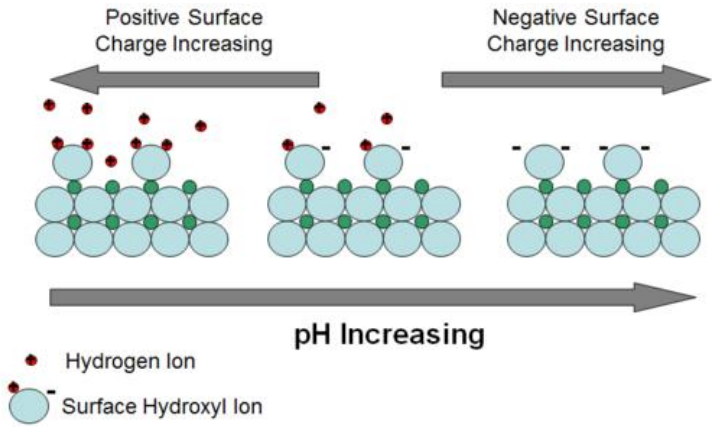
FTIR analysis



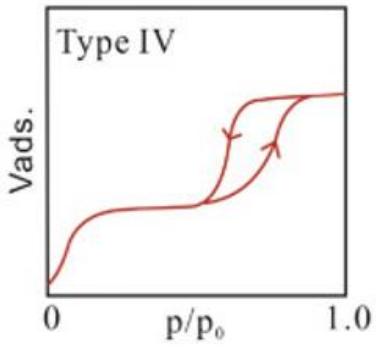
N_2 adsorption/desorption isotherms

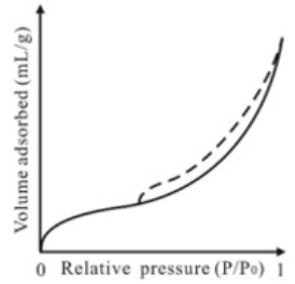


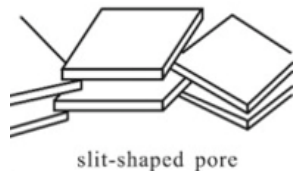




Ion Exchanger	X^{np}-La(III)
Specific surface area (S_{BET}) (m^2/g)	52.75
Total pore volume (V_t) (cm^3/g)	0.169
Average pore diameter (D_p) (nm)	12.79

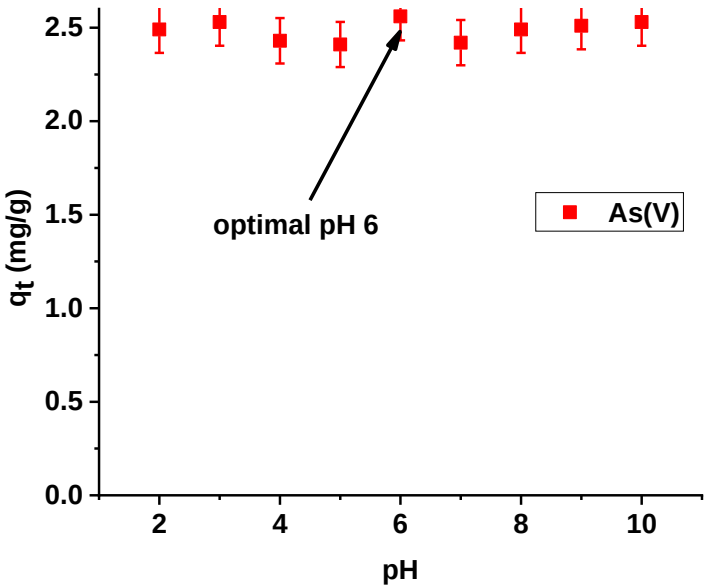






Arsenate(V) adsorption on X^{np}-La(III)

Effect of pH



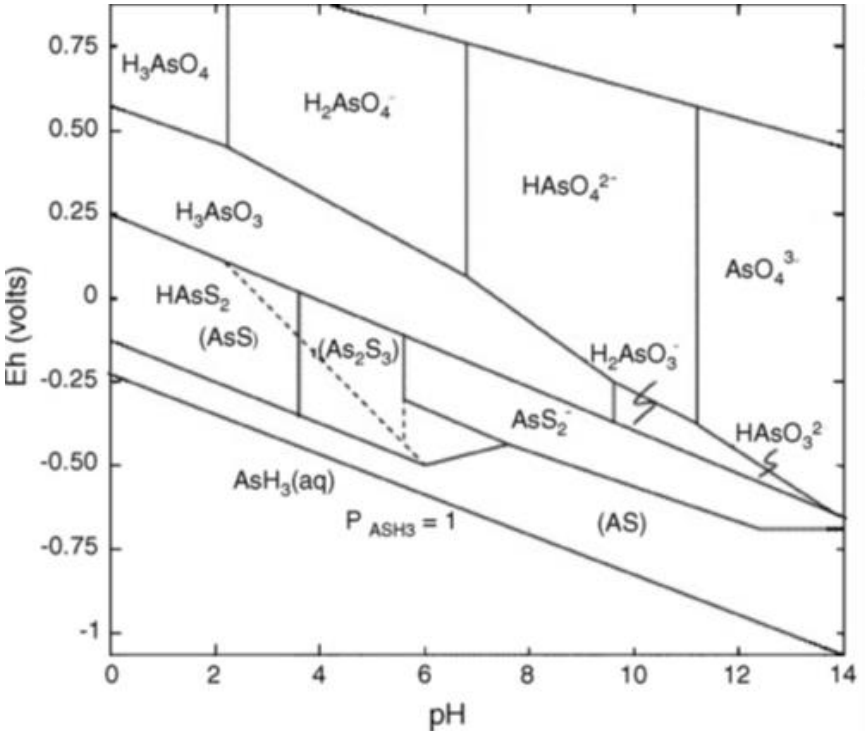
Effect of pH on adsorption of As(V) ions on X^{np}-La(III) (c_0 = 10 mg/dm^3, pH range 4-10, mass 0.1 g, time 360 min; temperature 295 K, shaking speed 180 rpm).

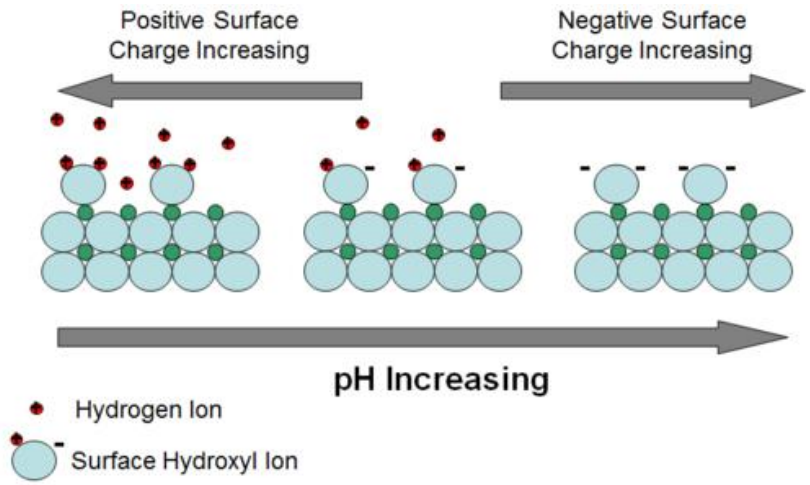
pH 6:

arsenate(V) ions

electrostatically attracted to

the positively charged surface

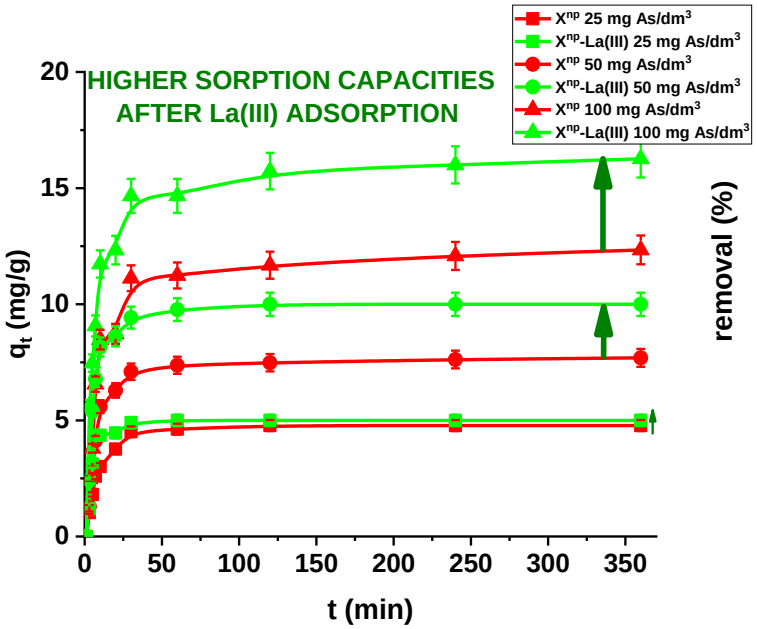


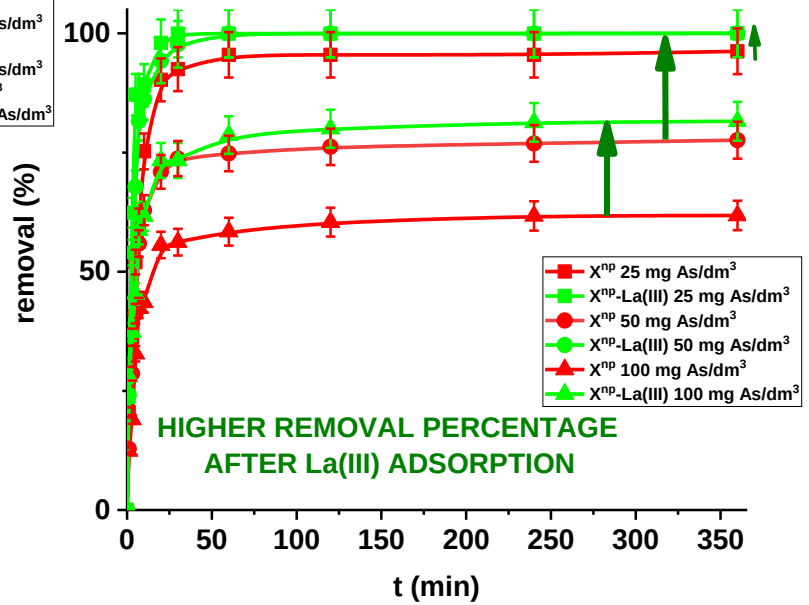


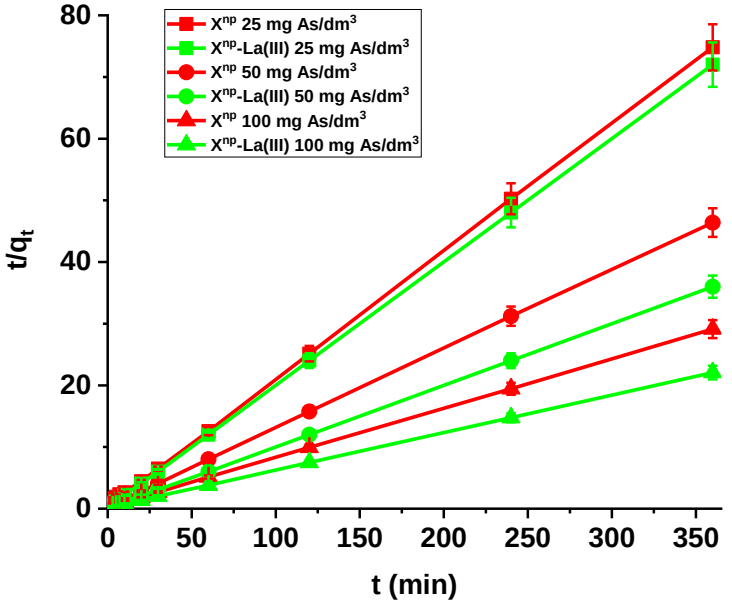
- ✓ formation of inner-sphere monodentate or bidentate complexes,
- ✓ formation of the lanthanum arsenate precipitate:

$$La^{3+} + H_2AsO_4^- \rightarrow LaAsO_4 + 2H^+$$

Kinetic studies







Kinetic Parameters	Xnp-La(III)-As(V)		
	25 (mg/dm³)	50 (mg/dm³)	100 (mg/dm³)
	PFO		
$q_{1,cal}$	0.29	1.34	5.09
k_1	0.029	0.036	0.021
R^2	0.4854	0.6614	0.8920
	PSO		
$q_{2,cal}$	5.02	10.07	16.46
k_2	0.178	0.057	0.020
h	4.488	5.825	5.306
R^2	0.9999	0.9999	1.0000

q_{exp} = 5.00 mg/g

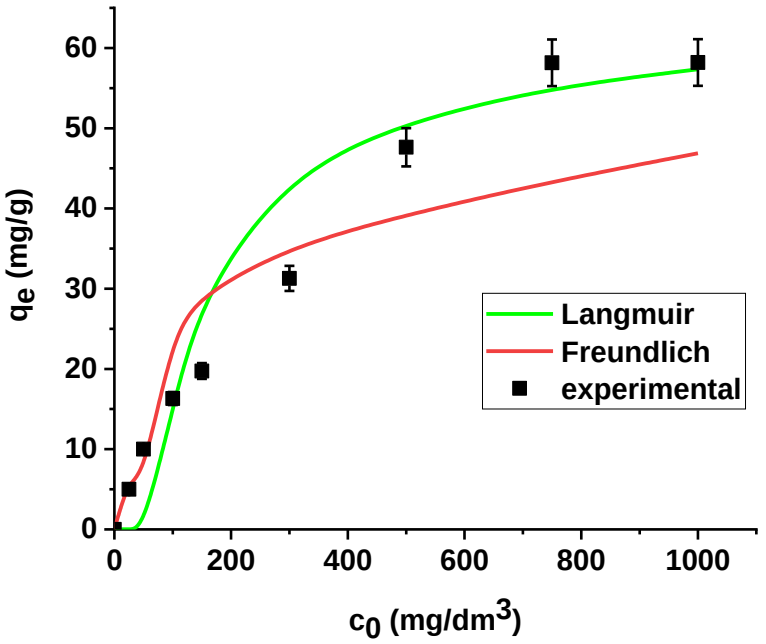
q_{exp} = 10.00 mg/g

q_{exp} = 16.31 mg/g

CHEMISORPTION

Better fit of experimental data ➔ PSO

Equilibrium studies



Isotherm Parameters	Xnp-La(III)-As(V)
Langmuir Model	
q^0	61.97
K_L	0.017
R_L	0.696
R^2	0.9637
Freundlich Model	
K_F	14.49
n	5.589
R^2	0.8611

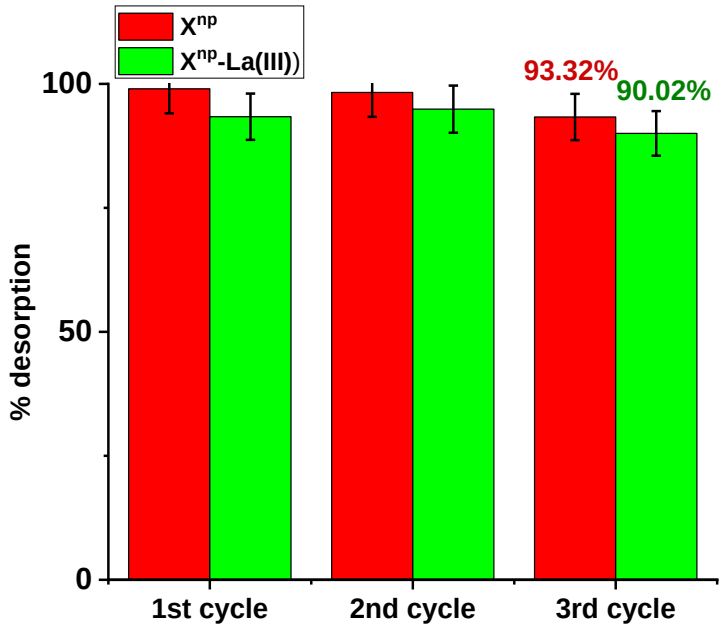
q_{exp} 58.19 mg/g (modified)

q_{exp} 21.21 mg/g (unmodified)

favourable adsorption

better fit than Freundlich model

Reusability of X^{np}-La(III)



Desorbing agent: 1M NaOH

After 3 cycles sorption-desorption: 16.31 mg/g ➔ **14.68 mg/g**

still better than X^{np} (12.36 mg/g)

Conclusions

- ✓ The maximum sorption capacity for arsenic(V) ions was almost 3 times greater after the modification.
- ✓ X^{np}-La(III) removed arsenic entirely from the solution of 50 mg/dm^3 in a relatively short time (about 2 h).
- ✓ It was found that after modification the sorbent can be successfully reused for purification of water contaminated with arsenic. After 3 cycles of adsorption and desorption, no significant decrease in the process efficiency was observed.
- ✓ Under almost neutral conditions precipitation and adsorption can be the main mechanisms of As(V) removal. After modification, the removal capacity was enhanced by the co-precipitation and adsorption by exchange of the OH− group with arsenic ions.
- ✓ The modification process itself is a great opportunity to improve the properties of iron oxide containing sorbents and to achieve the WHO restrictive limit for arsenic.

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Thank you for your attention!