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A granular Cu-modified chitosan biocomposite for sulfate removal from laboratory and groundwater sources

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INTRODUCTION & AIM

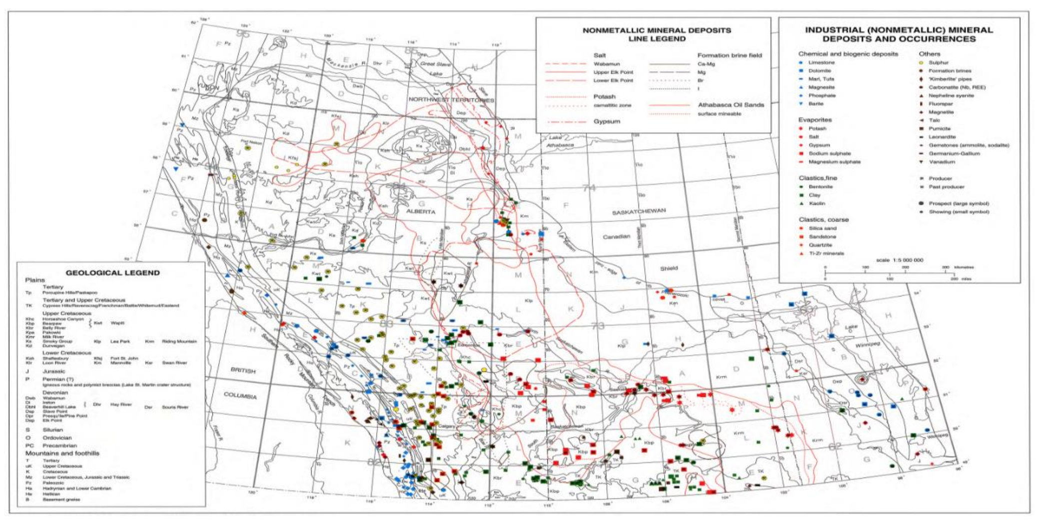
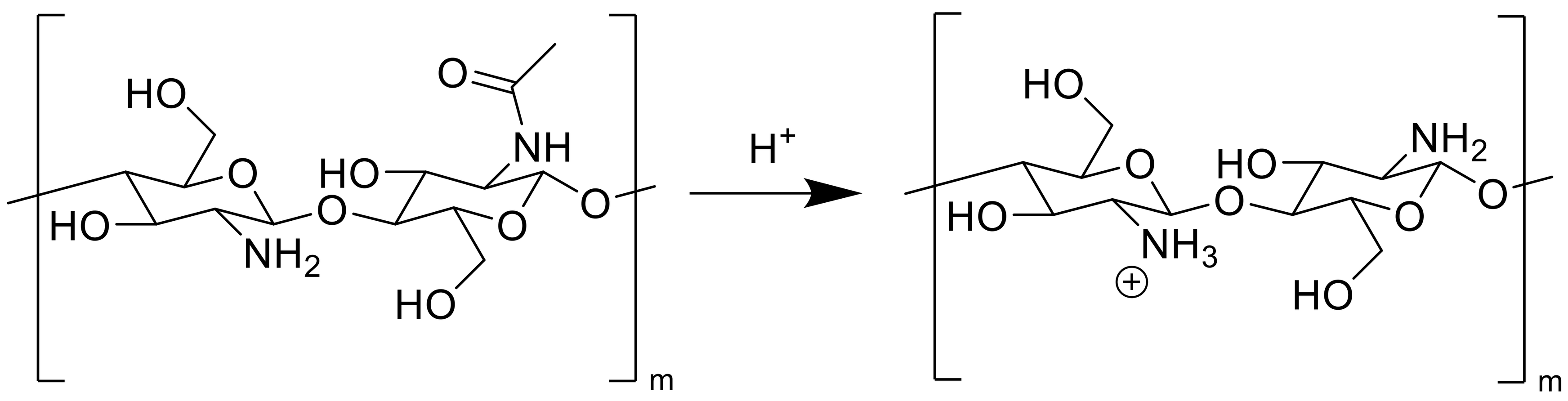


Figure 1: Map of non-mineral deposits (industrial) in the Western Canada Sedimentary Basin..

Sulface is abundant in water sources through anthropogenic and geological sources; Sulfate presents major challenges for livestock production from Cu-defency, lowered productivity to death in extreme cases;
In 1989 the average sulfate concentration was ca. 600 mg/L, and 18% of farms exceeded 1000 mg/L

Today: Up to 24,000 mg/L or higher sulfate concentrations in extreme cases;
Thresholds for max. Sulfate concentration range between 250-500 mg/ for humans and up to 1000 mg/L for livestock;
Easy, cheap and facile remediation techniques are still required;
Agro/Food wastes and biopolymers present affordable and sustainable platform materials for adsorbent preparation;

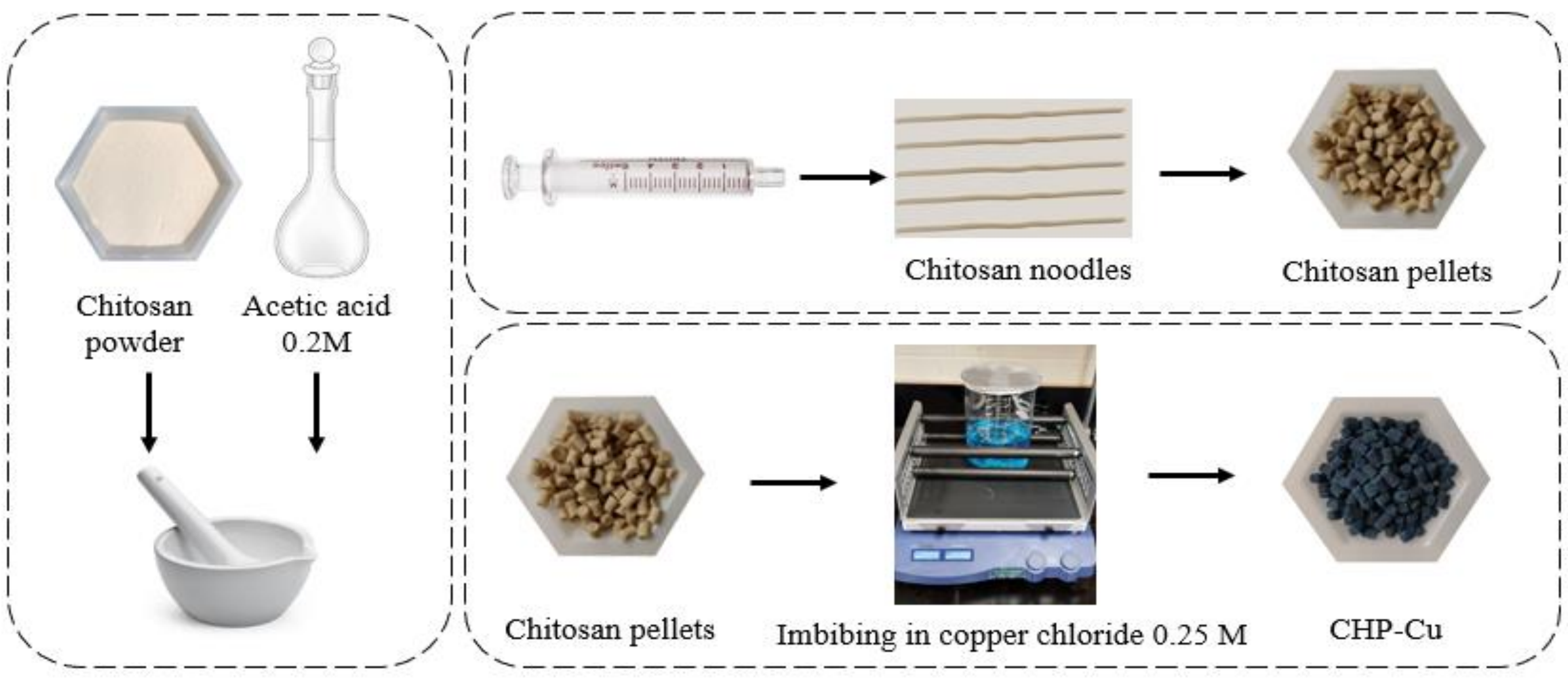


Scheme 1: Chemical structure of chitosan (50% deacetylated) & protonation of chitosan's amine group which is often derived from food waste such as crustaceans .

Objectives

Low-cost modification of chitosan to enhance adsorption performance;
Use pelletized adsorbents (granules) to offer benefits over powdered adsorbents for dynamic column studies;
Evaluate the effect of Cu-imbibing and investigate the performance in groundwater (well water) samples;

METHOD



Scheme 2: Conceptual illustration of the preparation method for chitosan-Cu(II) pellets (CHP-Cu): (i) blending; (ii) extrusion and drying; and (iii) Cu(II) imbibing step and drying.

Create paste from chitosan and acetic acid, extrude, cut into ca. 5 mm long pellets; dry at ca. 22 °C, imbibe in Cu solution; wash & dry

RESULTS & DISCUSSION

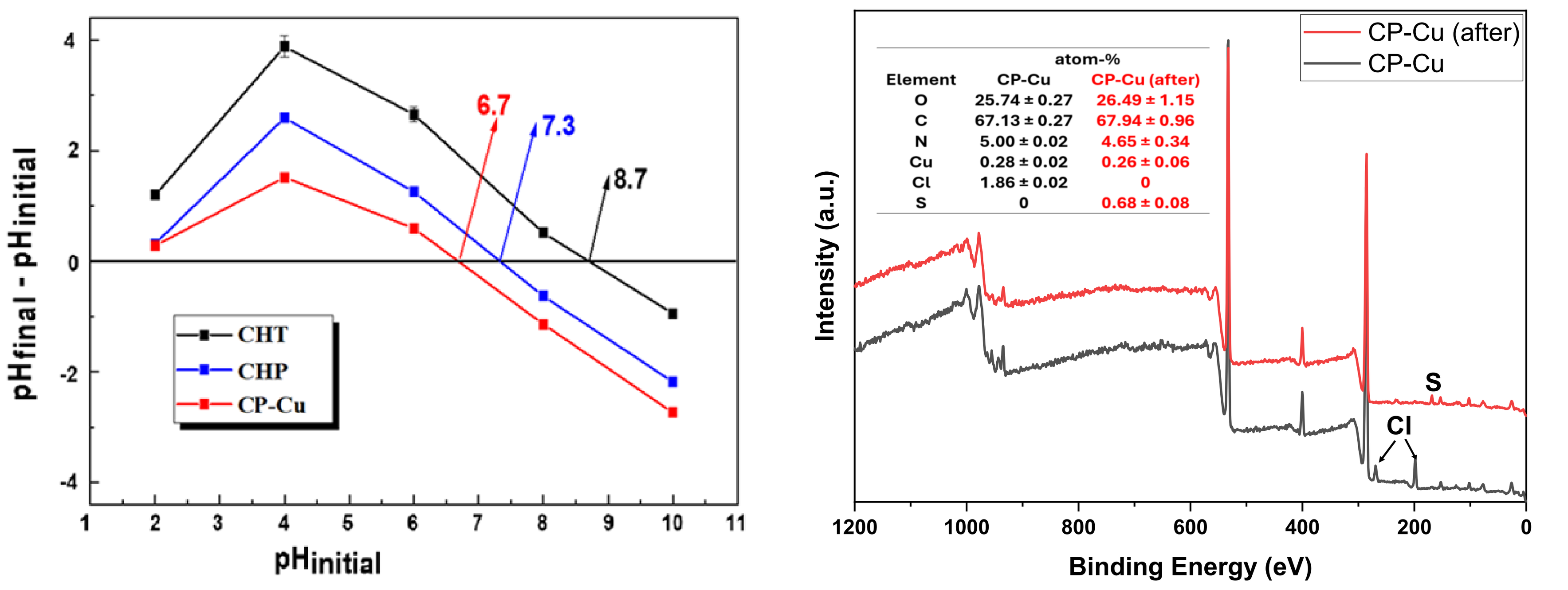


Figure 2: Point-of-zero-charge analysis of chitosan (CHT), chitosan pellets (CHP) and Cu-modified pellets (CP-Cu) (a); XPS analysis to elucidate the adsorption mechanism (b).

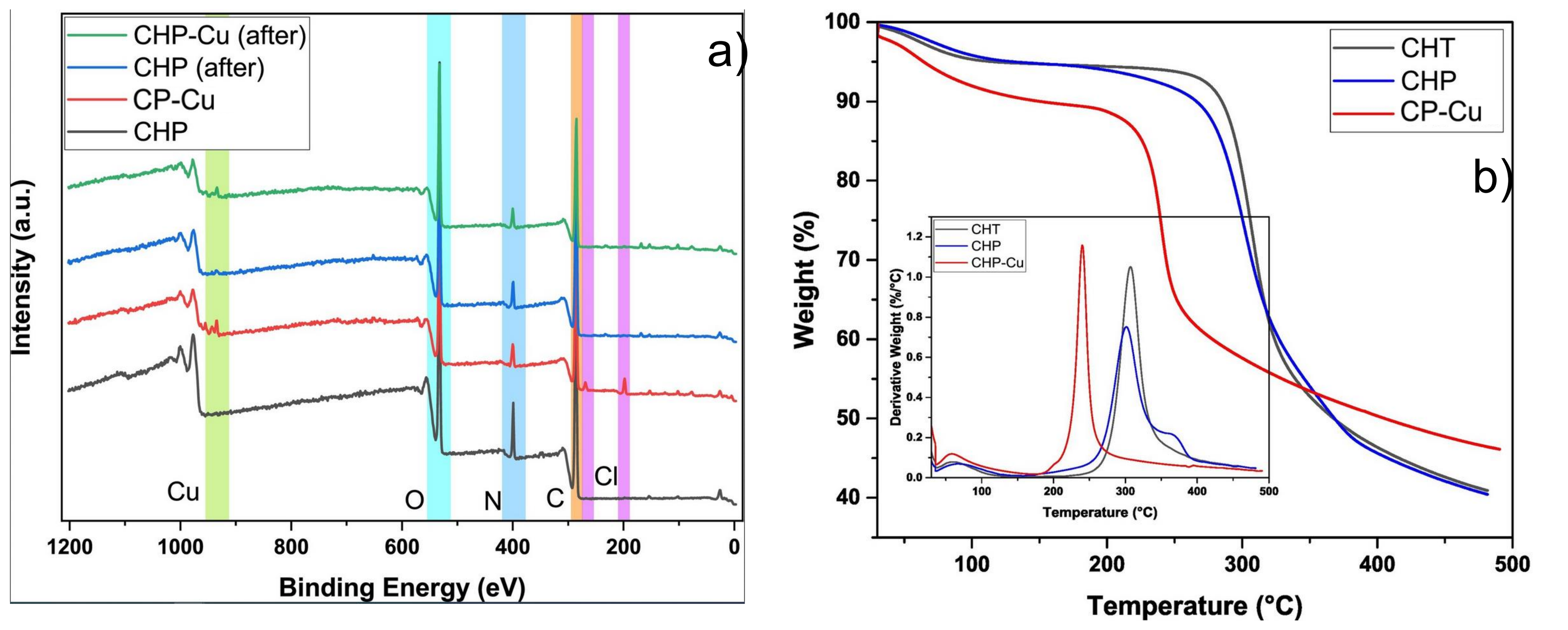


Figure 3: XPS to investigate adsorption mechanism (a); Thermogravimetric analysis of pellets with and without Cu (b).

Chitosan without base observes a point-of-zero charge of ca. 8.7, while Cu-imbibing decreases it to ca. 6.7; Cu-imbibing decreases thermal stability compared to chitosan; The adsorption mechanism was evidenced through X-Ray Photoelectron Spectroscopy (XPS) and could be shown to be anion exchange (chloride vs. sulfate); Isotherm studies showed a maximum adsorption capacity (equilibrium) of 407 mg/g (Sips).

Table 1: Dynamic adsorption experiments in laboratory water (pH 7.2, 295K).

	CHP		CP-Ca		CP-Cu
pH	4.5	6.5	4.5	6.5	7.2
mg g^{-1}	27	35	30	47	142

Table 4: Comparison of dynamic uptake capacities of CP-Cu in 4 different well water samples with varying sulfate concentration

	Well 4	Well 1	Well 2	Well 3
pH	8.3	7.7	7.8	7.5
C_0 (mg L^{-1})	892	2105	2753	6772
Uptake (mg g^{-1})	120	134	144	153

CONCLUSION

Ca imbibing did not appreciably improve the adsorption capacity; Cu imbibing, in contrast, allowed for high removal at neutral pH which was unaffected by the sample matrix (142 mg/g in laboratory vs 120-153 mg/g in different well water sources).

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