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Optimization of Malachite Green Adsorption onto Biocomposite Beads: A Sustainable Approach for Wastewater Treatment

AUTHORS

Drai Ikram [1], Bachir Cherifa [1], Keddou Adel [2], Elomari Kawthar [3]

AFFILIATIONS

[1] Laboratory of Applied Chemistry LAC, Institute of Science and Technology, University of Ain-Temouchent, Algeria.
[2] Laboratoire de Matériaux et Environnement LME, Université de Médea, Médea, Algérie.
[3] Laboratoire de Matériaux LABMAT, Ecole National polytechnique d'Oran Maurice-Audin ENPO-MA, Oran, Algérie.

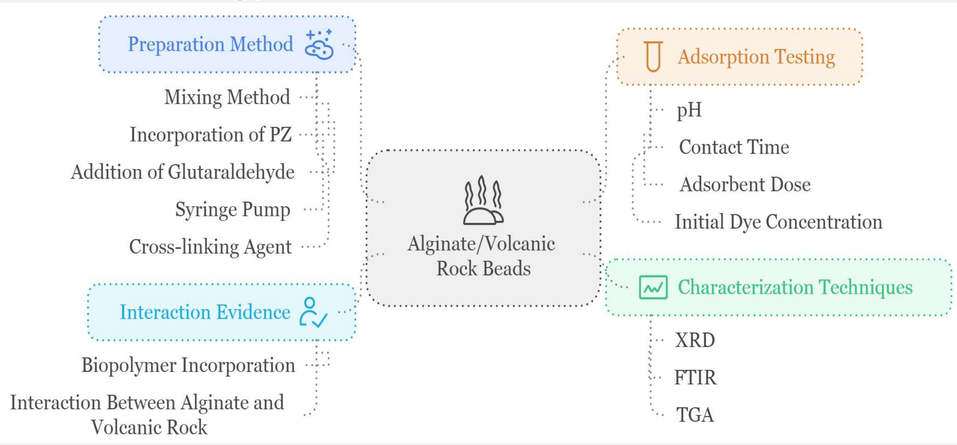
01. Introduction

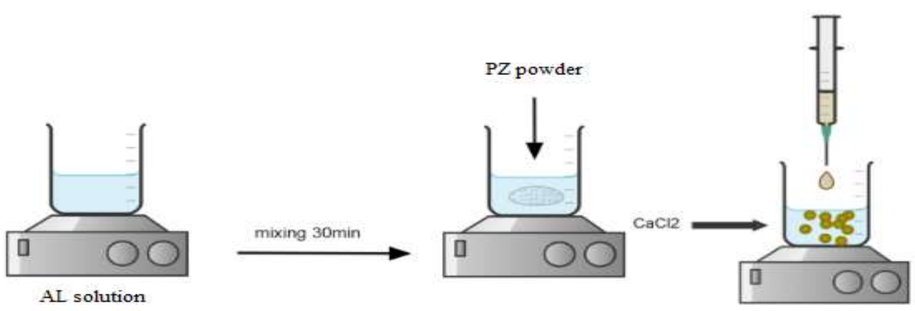
- Nature often inspires new ideas, especially for making eco-friendly materials. In recent years, people have shown more interest in green bio-composites used in the cleaning of industrial wastewater. The present research work aims at developing a sustainable and low-cost hybrid material by mixing natural volcanic rock (VR) from Ain-Temouchent, Algeria, with the biopolymer alginate (Alg).
- The Alginate/Volcanic Rock (Alg/VR) beads are a good way to help reduce water pollution. They are easy to make and can effectively remove harmful substances, making them a great choice for tackling pollution from industries. This fits well with worldwide goals for taking care of the environment.

02. Objective

- ✓ Advance green technology using natural, low-cost materials for water pollution control.
- ✓ Create Alg/VR hybrid beads using volcanic rock.
- ✓ Investigate alginate-volcanic rock interactions through advanced techniques (XRD, FTIR).
- ✓ Prove the scalability of Alg/VR beads for Malachite Green (MG) dye removal as a sustainable solution.

03. Methodology





04. Analysis

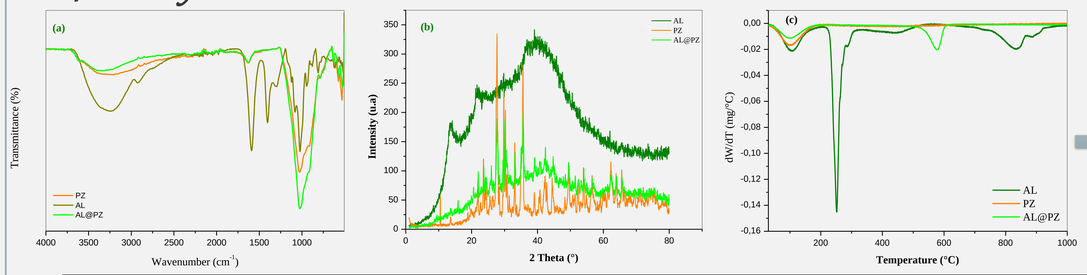


Figure 1: Analysis results of pure AL , PZ, and AL@PZ : (a) FTIR Analysis; (b) XRD Analysis ; (C) DTG Analysis.

Results/Findings

- FTIR : Good Encapsulation and Interaction
- XRD : Structural Integrity and Incorporation
- DTG : Better Thermal Stability

05. AL@PZ beads application: MG dye removal

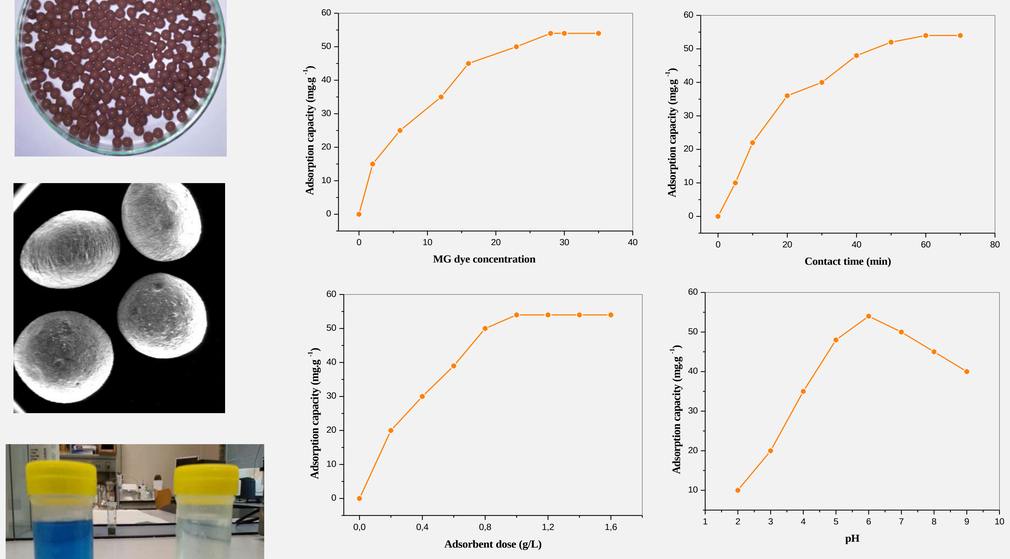


Figure 2: Optimization adsorption capacity of MG into AL@PZ beads: (a) MG dye concentration; (b) Contact time; (c) Adsorbent dose; (d) pH.

- **Dye Concentration**: Maximum capacity of 58 mg/g at 30 mg/L
- **Contact Time**: Stabilization at 60 minutes with 58 mg/g
- **Adsorbent Dose**: Optimal dose of 1.2 g/L yielding 58 mg/g
- **pH Level**: Maximum capacity at pH 6

06. Conclusion

Conclusion: The Alg/VR beads represent a nature-inspired solution to modern challenges and provide excellent dye removal efficiency of 95% while promoting sustainability. This green solution sets the stage for scalable, eco-friendly technologies in wastewater treatment.

Related literature

[1] Zhang, C.; Zhong, Z.; Feng, Y. J.; Sun, L.; Qi, L., Potential for phosphorus removal in wastewater using volcanic rock as adsorbent. Advanced Materials Research 2014, 1010, 202-206.

[2] Dutta, S.; Gupta, B.; Srivastava, S. K.; Gupta, A. K., Recent advances on the removal of dyes from wastewater using various adsorbents: A critical review. Materials Advances 2021, 2 (14), 4497-4531.

[3] Al-Gethami, W.; Qamar, M. A.; Shariq, M.; Alaghaz, A.-N. M.; Farhan, A.; Areshi, A. A.; Alnasir, M. H., Emerging environmentally friendly bio-based nanocomposites for the efficient removal of dyes and micropollutants from wastewater by adsorption: a comprehensive review. RSC advances 2024, 14 (4), 2804-2834.