Colorimetric Arsenic Detection at Micromolar Concentrations and Machine Learning Assisted Development of a Composite Teabag for Arsenic Bioremediation in Drinking Water

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Arsenic (As) is a known carcinogen, and its contamination of groundwater is a major global public health concern, with approximately 200 million people at risk of arsenic poisoning. Addressing this problem requires both accessible detection methods and scalable remediation technologies. To improve field detection, I developed a simple, low-cost arsenic assay based on the dissociation of NaAsO2 with HCl and KIO3 to form AsI3, producing a strong yellow color suitable for rapid visual identification of contaminated water. For remediation, I designed a cellulose-based system using Bemliese teabags embedded with magnetic iron oxide nanoparticles and filled with pulverized eggshells. The teabag is significantly more effective and cheaper than reverse osmosis and achieved >98% arsenic removal from a 35 mg·L?¹ NaAsO2 solution within 6 h. While the teabag demonstrates exceptional remediation efficacy, identifying optimal adsorption materials through experimentation alone is nearly impossible given the large number of possible adsorbents and surface modifications. To address this, I developed a machine-learning framework trained on both experimental and literature adsorption datasets to predict As removal performance and identify promising material optimization strategies. The model achieved very strong predictive performance (R^2 = 0.83, MAE = 6.11%) and was used to propose modification pathways that improve adsorption efficiency across diverse low-cost materials. Together, the integration of a novel detection method, a composite teabag, and machine learning based materials optimization offers a scalable strategy for addressing As contamination in drinking water.

Awards Won:

Second Award of $2,400

Chemistry and the Law: First Award of $4,000