ACTIVATION AND REGENERATION OF WALNUT SHELLS APPLYING COLD PLASMA TECHNOLOGY AND ITS EFFECTS ON THE ADSORPTION OF METHYLENE BLUE FROM AQUEOUS SOLUTIONS

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Adsorption is a process commonly used to remove organic pollutants from water exhibiting advantages like effectiveness, fast removal, low-cost and no need of additional chemicals. Especially, materials deriving from agricultural wastes is an important class of adsorbents being naturally abundant. The main limitation of this method is that the organic pollutants are transferred from the aqueous to the solid phase (adsorbent). Therefore, adsorption is not a permanent solution and further treatment is required. Cold atmospheric plasma is a novel process applied for the modification of materials as well as for the destruction of organic molecules. Its action is based on the highly oxygen and nitrogen reactive species (RONS) generating during plasma discharges. In this study, a novel approach was applied in which plasma has a dual role. Firstly, plasma was applied for the activation of agriculture wastes (walnut shells) in order to increase their effectiveness on the adsorption of a common organic pollutant (i.e. methylene blue, MB) from water. The alteration of the removal efficiency before and after adsorbent activation by the cold plasma was recorded. Secondly, plasma bubbles were used to regenerate the spent adsorbent and reuse it. The latter is an important feature towards the sustainability of the method addressing the main limitation of adsorption process.
The effectiveness of walnut shell powder to remove the cationic dye MB from aqueous solution was examined following batch kinetics and isotherm studies. After being modified by cold plasma, the maximum adsorption capacity, as compared to untreated raw walnut shells, increased from 56.18 to 118.19 mg/g. MB adsorption onto walnut shells was better described by Freundlich model and the experimental data are well fitted with the pseudo-second order model suggesting that the predominant adsorption mechanism was chemisorption (through electrostatic interactions). The saturated adsorbent was regenerated inside a plasma microbubble reactor and its adsorption capacity was re-tested by applying new adsorption cycles. Plasma bubbling was able to efficiently regenerate saturated walnut shells with low energy requirements (33.3 Wh/g-adsorbent). Most importantly, when applied to new adsorption cycles, the increased adsorption capacity of the plasma-regenerated WS's (compared to plasma-activated walnut shells) indicated that further activation of the adsorbent was accomplished during the regeneration process. The present study provides a green, sustainable and highly effective alternative for water remediation addressing important limitations.

KEYWORDS: Cold plasma, Adsorption, Activation, Regeneration, Walnut shells, Methylene blue

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