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REMOVAL OF METHYLENE BLUE DYE FROM AQUEOUS SOLUTIONS USING LEMON POWDER AND DERIVED ADSORBENTS

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Introduction

Water pollution caused by synthetic dyes is a major environmental problem, as these compounds affect aquatic ecosystems, reduce light penetration, and can have toxic, mutagenic, or carcinogenic effects. Due to their chemical stability, it is difficult to remove these dyes using conventional methods. A sustainable alternative for their removal is the use of waste biomass, particularly citrus peels, which are ground into powder after drying and milling. These peels contain lignocellulosic compounds and active functional groups that promote the adsorption of dyes through various chemical mechanisms. The use of citrus peels as biosorbents offers advantages such as low cost, high availability, biodegradability, and a contribution to the circular economy, representing a promising solution for wastewater treatment and reducing environmental impact. This study investigated the effectiveness of lemon peel powder and activated carbon (AC) treated with sodium hydroxide (basic AC) and orthophosphoric acid (acid AC), respectively, in adsorbing methylene blue dye from aqueous solutions.

Materials and methods

Methyl Blue (MB, purity ≥ 60%), acetonitrile, methanol, ammonium acetate, orthophosphoric acid (85%), and sodium hydroxide (50%), all reagents from Sigma-Aldrich, Germany. The primary standard solution, with a concentration of 1000 mg/L, was prepared in methanol. Individual dilutions and mixed standard solutions of the analytes were prepared in ultrapure water. All solutions and dilutions were stored in the refrigerator at 4°C. Lemon powder (LP) is obtained by collecting, washing, drying, grinding, and sieving lemon peels, resulting in a material with properties suitable for adsorption. From this, activated carbon is prepared through chemical activation in acid or basic medium, followed by heat treatment, washing, neutralization, and drying. Both materials develop a porous structure and a high number of active sites, making them effective for adsorbing synthetic dyes and other pollutants from water.

To evaluate the adsorption process, the following parameters were investigated: pH (1, 3, 5, 7, 9, and 11 pH value), contact time (0, 2, 4, 6, 8, 22, and 24 h), and adsorbent dose (25, 50, 75, 100, and 150 mg), using 50 mL of a methylene blue solution with a concentration of 150 mg/L, and for the pH and contact time studies, 100 mg of adsorbent was used, with a contact time of 24 h for the dose study.

Results and conclusions

The research results indicated that the chemical activation of lemon powder significantly improves the material's adsorbent properties. The influence of pH was investigated, and the results showed that maximum adsorption efficiency was achieved at pH 11 for Basic AC (removal efficiency of approximately 32%) and LP (removal efficiency up to 21%). For the Acid AC material, the maximum removal efficiency was up to 22%, at pH=3 (Figure 1).

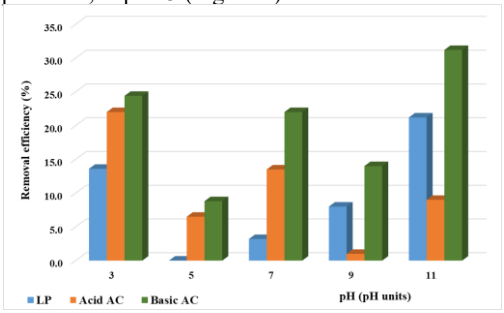


Figure 1 - Influence of pH on removal efficiency

According to the contact time, Figure 2, the maximum adsorption capacity was 34 mg/g for LP, 65 mg/g for acidic AC, and over 64 mg/g for basic AC, with the last one also offering the fastest adsorption kinetics.

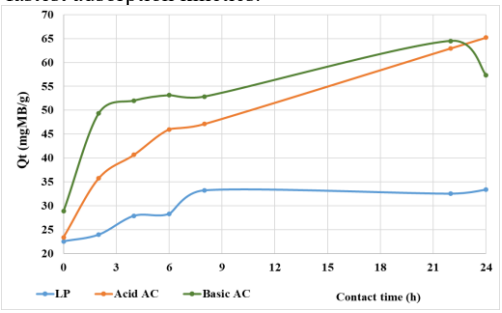


Figure 2 - The effect of contact time on the adsorption capacity of materials

Increasing the amount of adsorbent resulted in a maximum recovery of approximately 60% for acid AC at 150 mg, while basic AC achieved its maximum efficiency (26%) at 25 mg of adsorbent. Isotherm analysis indicated a maximum adsorption capacity (Qmax) of 29.85 mg/g for lemon powder, 64.10 mg/g for acid AC, and 217.4 mg/g for basic AC. The pseudo-second-order kinetic model best described the adsorption process, with R^2>0.98 for all materials.