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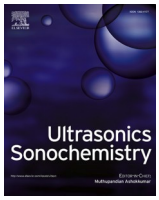

An eco-friendly ultrasound approach to extracting yellow dye from *Cassia alata* flower petals: Characterization, dyeing, and antibacterial properties

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ABSTRACT

Using natural dyes in dyeing industries becomes an alternative to synthetic dyes, which are known to contain harmful chemicals that can pose risks to the environment and human health. This study involves the extraction of yellow dye from *Cassia alata* flower petals, optimization of the extraction process using an ultrasonic bath (40 KHz and an input power of 500), ultrasonic probe (390 W, 455 W, 520 W, 585 W, and 650 W), and conventional heating (heating mantle with 30 °C, 40 °C, 50 °C, 60 °C, and 70 °C), characterization of the dye, as well as dyeing (cotton, silk, and leather) without using a mordant. The extracted yellow dye was further evaluated to determine its antibacterial activity against skin bacteria. Dye extraction optimization using UV–Visible spectrophotometric analysis revealed that the maximum yellow color in methanol extract (287 and 479 nm) was obtained at 50 °C for 45 min using ultrasonic water bath extraction, followed by the ultrasonic probe and direct heating. Based on the FTIR spectra, it is evident that O—H is present at approximately 3300 cm^{-1}, while C—H stretches at around 2900 cm^{-1}. A characteristic peak at 1608 cm^{-1} bears a striking similarity to anthraquinonoid-based compounds. Also, using the ultrasonic water bath dyeing technique at 50 °C for 45 min, the yellow color of cotton, silk, and leather was dyed optimally. Due to effective color removal after two washings with boiling soap liquid, the dyed cotton and silk fabric displayed good washing and rubbing fastness. Regarding antibacterial activity, the dye was highly active against all pathogens after extraction in methanol. The maximum inhibition was observed against *Pseudomonas* sp. with a MIC value of 1.56 mg/ml.

1. Introduction

In textile dyeing, natural or synthetic dyes add color to fibers, yarns, or fabrics. The textile industry has greatly benefited from synthetic dyes due to their advantageous characteristics and user-friendliness. However, synthetic dyes have been associated with harmful environmental and human health effects. Most artificial dyes are produced from non-renewable petroleum sources, requiring significant energy. Water generated by synthetic dyeing processes has hazardous environmental effects and poses health risks [1,2]. The use of natural dyes has been around for thousands of years. They are environmentally friendly, renewable, and biodegradable. Their aesthetic properties are unique, and every plant-based dye has a unique chemical composition, resulting in a distinct color and shade. Natural dyes can achieve various colors,

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