ABSTRACT

The increase in polypropylene (PP) waste from protective gear during and after the COVID-19 outbreak has intensified plastic waste management challenges. This thesis explored innovative methods for valorizing waste PP to address environmental issues and create advanced materials. A mesoporous PP scaffold with a surface area exceeding 170 m^2/g was developed using emulsion templating, confirmed by BET and SAXS analyses. This scaffold demonstrated a high oil adsorption capacity of 7.5 g/g for petrol, comparable to commercial PP absorbent pads. A 3D-printed funnel achieved a 99.8% separation efficiency for petrol/water mixtures over ten cycles without performance degradation. To tackle heavy metal pollution, a PP-based sensor for detecting copper ions (Cu^{2+}) in blood and water was created. The sensor, decorated with benzothiazolinium spiropyran (BTS), produced a reddish color upon Cu^{2+} exposure, with a detection limit of 1.3 ppm. Its reversibility was confirmed through cyclic exposure to visible light and XPS analysis. The scaffold was also functionalized with chemically modified calixarene (CMC) for strontium ion (Sr^{2+}) adsorption, addressing radioactive pollution. Adsorption isotherms followed Langmuir and Freundlich models, with a maximum capacity of 131.74 mg/g. The pseudo-second-order kinetic model suggested chemisorption of Sr^{2+} ions by CMC hydroxyl groups. An antimicrobial PP scaffold was synthesized by grafting acrylic acid (AA) onto the PP scaffold *via* a Fenton reaction. Green-synthesized silver nanoparticles (AgNPs) using *Nyctanthes arbortristis* root extract were immobilized onto the scaffold, forming PP-g-AA-Ag composites. These exhibited significant antibacterial activity against *E. coli* and *S. aureus*.

Overall, this research demonstrated innovative approaches to repurpose waste PP into functional materials for environmental remediation and health applications, highlighting commercial scalability and broader applicability in plastic waste valorization.