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DESORPION OF RIFAMPICIN FROM PET FIBERS

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Introduction

The rapid increase in plastic production and consumption has created major waste management challenges worldwide. Polyethylene terephthalate (PET), one of the most widely used polymers for single-use bottles and packaging, is particularly problematic due to its persistence in the environment. Recycling PET into fibers provides a dual benefit: it reduces plastic waste and creates new applications for environmental remediation. At the same time, pharmaceutical pollutants are increasingly found in aquatic environments, with antibiotics being among the most concerning due to their persistence and contribution to antimicrobial resistance. Rifampicin, a key antibiotic used to treat tuberculosis and other infections, has been detected in wastewater effluents at notable concentrations. Its extensive use and poor biodegradability allow it to accumulate in natural waters, posing risks to ecosystems and human health. Adsorption has emerged as an effective approach for removing pollutants from water, and PET fibers have shown promising results, with over 40% rifampicin removal under optimized conditions. However, for practical applications, regeneration of the adsorbent is crucial. This study investigates the desorption of rifampicin from PET fibers using sodium chloride solutions, tap water, and a medical polyelectrolyte solution to assess the reusability of PET in pollutant removal systems.

Materials and methods

The experimental design aimed to evaluate the desorption of rifampicin from recycled PET fibers under controlled conditions. PET fibers were obtained from recycled plastics, aligning the study with the goal of plastic waste valorization.

Adsorption stage: Before desorption tests, adsorption was carried out under optimized conditions. The solution pH was adjusted to 2.0, the point where maximum adsorption was achieved. A PET dosage of 0.04 g/L was applied, with a contact time of 24 h at ambient temperature (23 °C). Using an initial rifampicin concentration of 42.2 mg/L, the adsorption capacity reached 44.62 mg/g, corresponding to a removal efficiency of 43.10%. Desorption agents: Three types of agents were tested. Sodium chloride (NaCl) solutions of varying concentrations were used to assess ion-exchange effects. Tap water was tested as a low-cost, easily available option. A medical polyelectrolyte solution (SW) was also applied, given its potential to interact strongly with rifampicin. Procedure: Rifampicin-loaded PET fibers were immersed in each solution and agitated. Supernatants were analyzed, and desorption percentages were calculated relative to the adsorbed antibiotic. This approach enabled systematic comparison of regeneration efficiency across agents.

Results and conclusions

The results of this study highlight the efficiency and versatility of recycled PET fibers as adsorbents for rifampicin, while also demonstrating their potential for reuse when paired with suitable desorption strategies. Figure 1(a) illustrates the adsorption process, where rifampicin removal reached significant levels under optimized conditions (pH 2.0, PET dosage of 0.04 g/L, 24 h contact time, 23 °C, and initial concentration of 42.2 mg/L). Under these conditions, the antibiotic removal efficiency was 43.10%, with an adsorption capacity of 44.62 mg/g, confirming PET fibers as cost-effective and sustainable materials for pollutant capture.

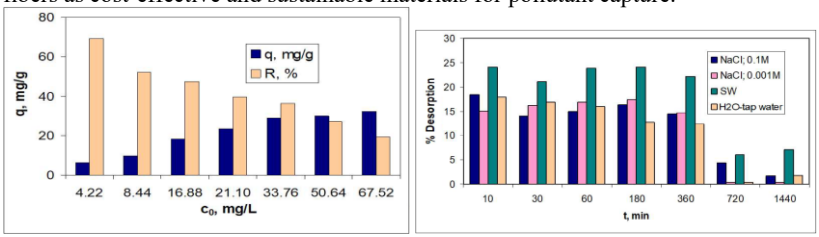

Figure 1. (a) Adsorption of rifampicin on PET fibres and (b) Desorption of rifampicin on PET fibres

The regeneration of fibers was further assessed through comparative desorption tests, as shown in Figure 1(b). Here, clear differences emerged depending on the desorption medium employed. Sodium chloride solutions, tested at two concentrations, induced partial release of rifampicin. This indicates that ionic competition can destabilize the antibiotic–fiber interactions, but the overall recovery remained modest. While higher salt concentrations slightly improved desorption percentages, the approach raises environmental concerns due to the possible introduction of secondary pollutants, which could limit its large-scale application.

In contrast, tap water produced negligible desorption. The extremely low release into the aqueous phase shows that strong interactions between rifampicin and PET cannot be reversed by simple rinsing, emphasizing the need for more targeted regeneration agents. The most effective performance was obtained using a medical polyelectrolyte solution (SW), which achieved over 36% desorption. This superior result suggests that the polyelectrolyte composition promotes complexation or enhanced solubilization of rifampicin, thereby weakening its bond with PET surfaces. These findings underscore the dual benefits of PET fibers: reducing plastic waste while mitigating pharmaceutical contamination. Their capacity for repeated adsorption–desorption cycles not only lower operational costs but also aligns with sustainable practices in environmental remediation and pharmaceutical waste management.

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