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Chitosan/Carboxymethylcellulose/Vanillin@Graphene oxide nanocomposites for the removal of ketoprofen and naproxen from wastewater

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INTRODUCTION & AIM

The COVID-19 pandemic has caused the increased use of non-steroidal anti-inflammatory drugs (NSAIDs), leading to their accumulation in wastewater, posing risks to human health and the balance of the ecosystem. Therefore, between 2019 and 2021, NSAIDs were detected in water sources at concentrations ranging from a few ng/L to hundreds of μg/L. The most commonly found drugs are diclofenac, ibuprofen, naproxen, acetaminophen, and ketoprofen etc. There are different several technique to reduce pollutants from wastewater such as chemical precipitation, coagulation/flocculation, etc., but adsorption technique is as a simple, sustainable, cost-effective, and eco-friendly method for pharmaceutical contaminant removal.

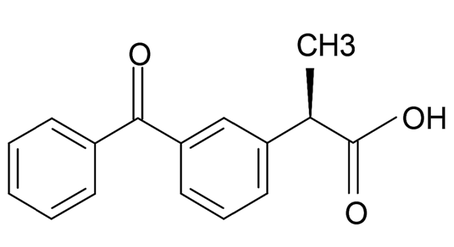

Fig 1. Chemical structure of ketoprofen

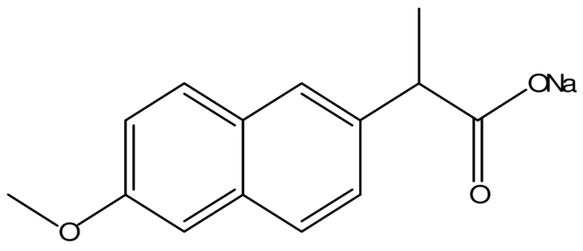

Fig 2. Chemical structure of naproxen

In this study, two nanocomposites, i.e. CS/CMC/VAN and the further modified CS/CMC/VAN@GO, were synthesized to remove ketoprofen (Fig. 1) and naproxen (Fig. 1) from aquatic solutions. Chitosan, a natural cationic polymer, is combined with vanillin via a Schiff base formation and offers effective and low-toxicity adsorption properties. Moreover, modified chitosan exhibits improved adsorption capacity when combined with carboxymethyl cellulose (CMC) and graphene oxide (GO), which are both known for their low toxicity and biocompatibility. In addition, graphene oxide GO is widely utilized in water treatment due to its high surface area, mechanical strength, and compatibility with various functional groups.

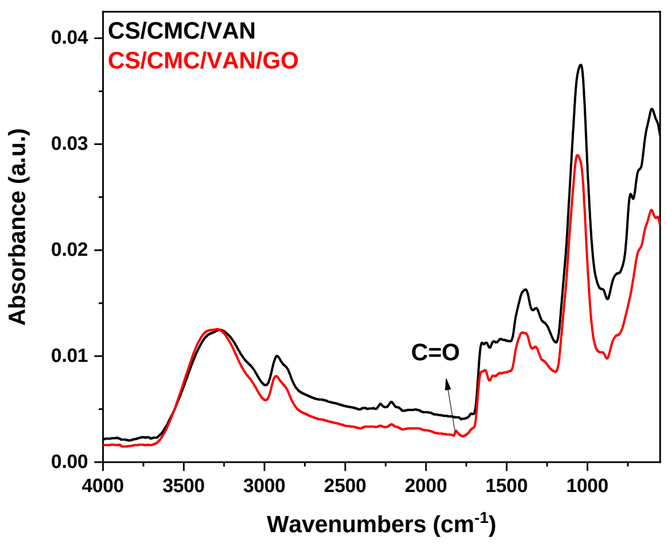

Fig 3. FTIR spectrum of CS/CMC/VAN and CS/CMC/VAN/GO

FTIR analysis of CS/CMC/VAN and CS/CMC/VAN/GO shows a shifted peak at 1655 cm^{-1}, attributed to the presence of GO (Fig. 3). SEM images reveal that CS/CMC/VAN has a more compact structure with small, evenly distributed pores and a smooth surface. In contrast, CS/CMC/VAN/GO shows a much rougher surface due to the presence of GO (Fig. 4).

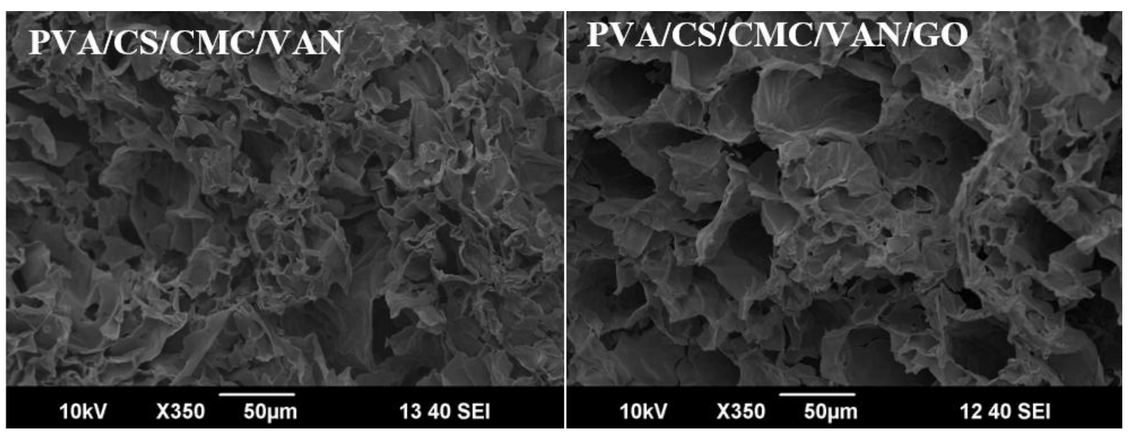

Fig 4. SEM images of CS/CMC/VAN and CS/CMC/VAN/GO

RESULTS & DISCUSSION

Adsorption evaluation include various experiments. First, the effect of pH is studied (Fig. 5), which determines the optimum pH value for effective removal of each pollutant. Additionally, kinetics studies are conducted (Fig. 6), applying different kinetic models to determine the type (physical or chemical) sorption. Finally, isothermal models, Langmuir and Freundlich (Fig. 7), provide information about whether the adsorption is monolayer or multilayer, as well as the adsorption capacity of adsorbents materials.

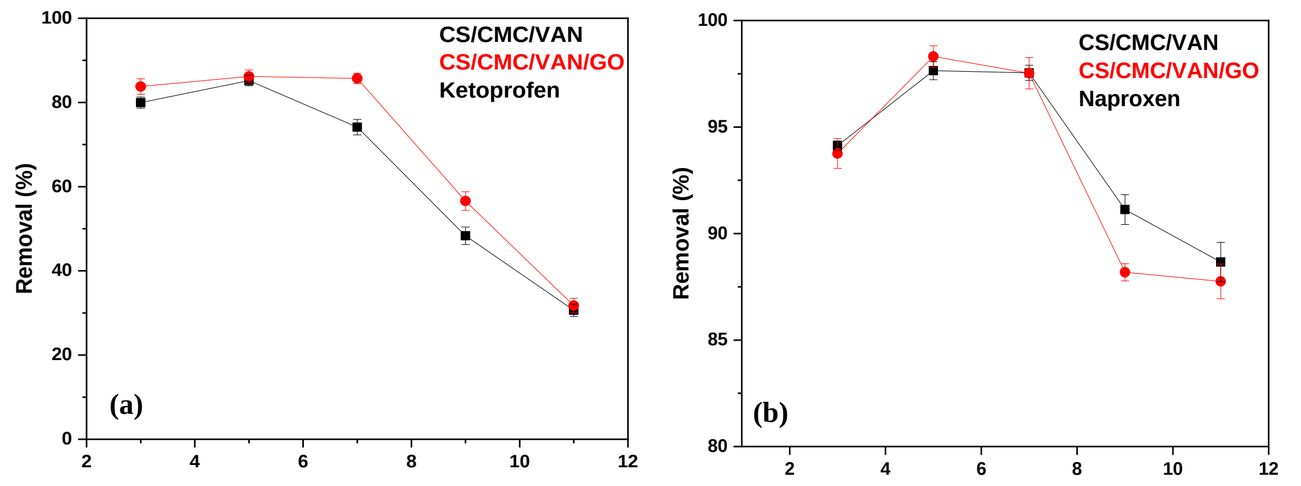

Fig 5. Effect of pH on the adsorption of (a) ketoprofen and (b) naproxen

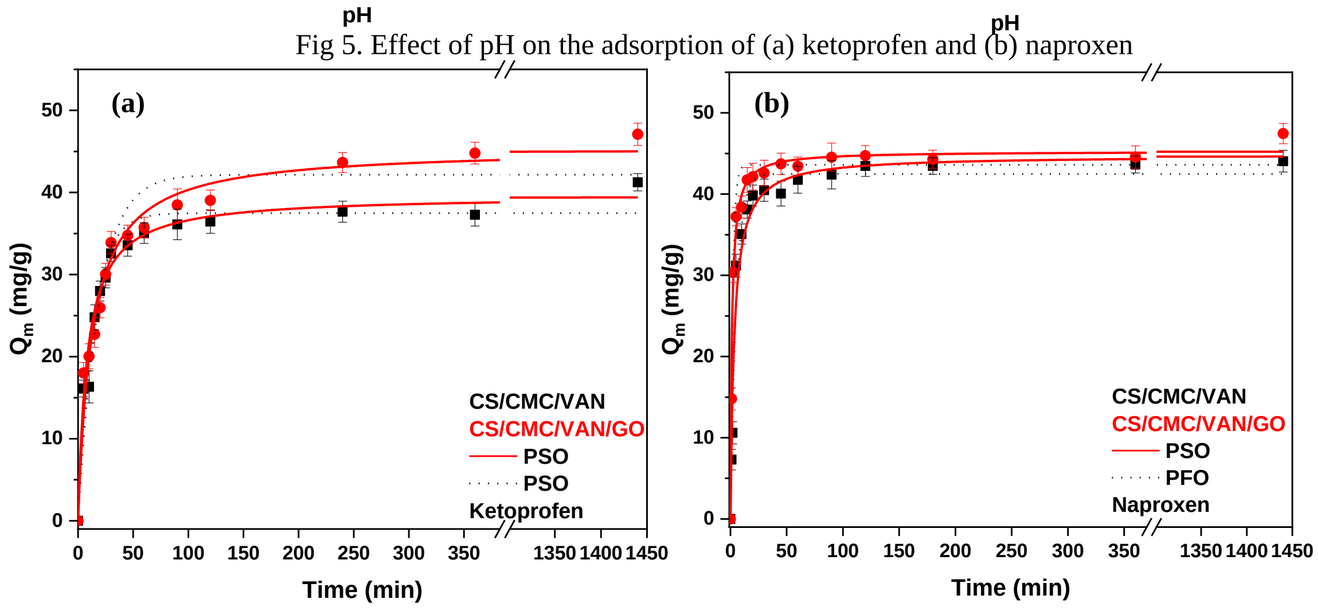

Fig 6. Kinetic study on the adsorption of (a) ketoprofen and (b) naproxen

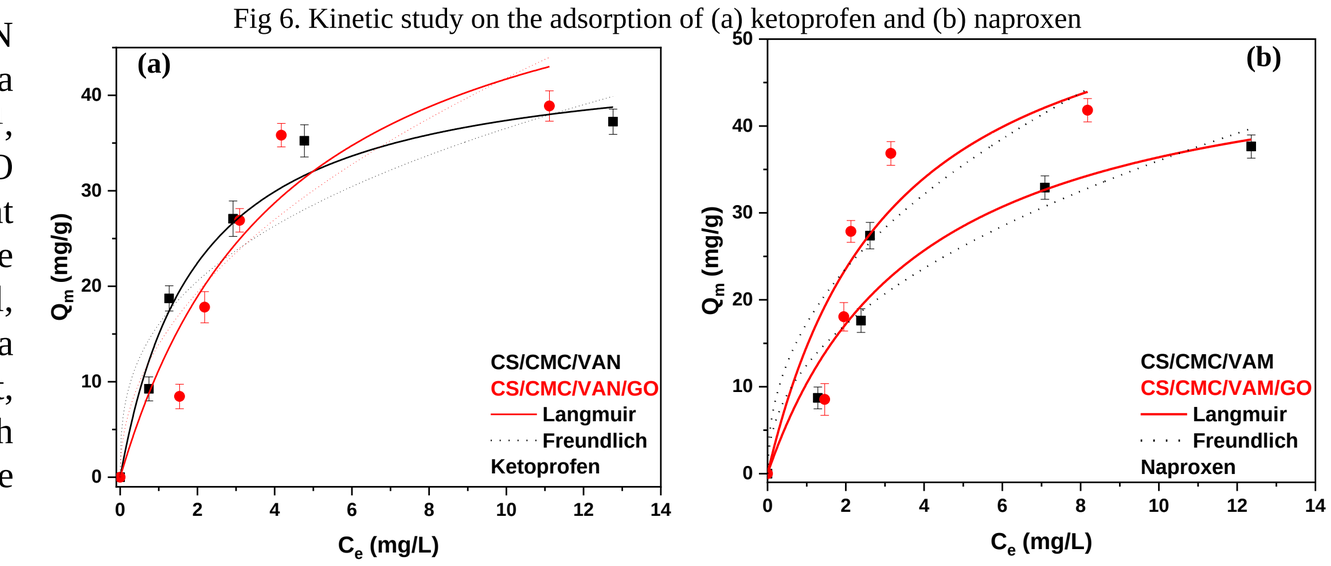

Fig 7. Isotherm study on the adsorption of (a) ketoprofen and (b) naproxen

CONCLUSION

In this study, two nanocomposites, CS/CMC/VAN and CS/CMC/VAN@GO, were synthesized to remove ketoprofen and naproxen. All the materials were characterized via FTIR and SEM techniques. Adsorption experimental results showed that the data fitted better to PSO model and Langmuir isotherm model, providing adsorption capacities equal to 51.29 mg/g for ketoprofen and 46.30 mg/g for naproxen with the optimum CS/CMC/VAN@GO at pH 5.

ACKNOWLEDGMENT

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