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Removal of Arsenic Anions by Adsorption onto Free and Immobilized Fungal Materials

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Abstract

As(V) contamination in water sources poses a threat to both humans and the environment. Traditional water treatment techniques have drawbacks such as inefficiency, high capital and operational costs^{1,2}. Biosorption and bioremediation can provide effective and inexpensive alternatives for As(V) removal³. *Mucor rouxii*, a filamentous fungus previously reported as an efficient biosorbent in Pb(II) removal⁴, was investigated as a potential biosorbent for the removal of As(V) ions in aqueous phase. The As(V) uptake of *M. rouxii* was found significantly improved after immobilization through cross-linking between the carboxymethyl cellulose (CMC) and Fe(III). Batch As(V) biosorption experiments on CMC-immobilized *M. rouxii* beads (CMCMR) reveal that the Sips isotherm could best describe the equilibrium data while the pseudo-second kinetic model provided the best simulation of the biosorption kinetics. The integrated results from FTIR, SEM-EDX and XPS analyses indicated the involvement of protonated amino groups and possible ion/ligand exchange between As(V) and other ions coordinated with Fe(III) on CMCMR in the As(V) uptake. The effective removal of anionic As(V) by CMCMR in this study demonstrates the great potential of this biomaterial for the treatment of As(V)-laden water.

Introduction

Biosorption is considered a potential alternative for treatment of heavy metal-contaminated water sources. Immobilization of fungal materials can enhance the rigidity and mechanical strength of native fungal biomass and facilitate the separation of biosorbents from treated effluent and the reuse of the biosorbents. In this study, the biosorption performance of free and CMC-immobilized *M. rouxii* (FMR and CMCMR, respectively) on As(V) removal was evaluated.

Methods

Preparation of fungal biomass and immobilization

M. rouxii was cultured for 2 d using YPG medium at pH 4.5, 30°C and 250 rpm. Freely suspended *M. rouxii* (FMR) was mixed with 4% Na-CMC solution at a biomass to CMC mass ratio of 1:1 and dripped into 0.05 M FeCl₃ to form CMC-immobilized *M. rouxii*.

Batch biosorption experiments

Batch biosorption experiments were carried out at pH 4.0, 25°C and 250 rpm. Arsenic concentration was determined by ICPOES.

Results & Discussion

Biosorption isotherm

The isotherm results indicate that As(V) uptake increased with the equilibrium metal concentration (C_e). It is found that the equilibrium data of both FMR and CMCMR could be best described by the Sips isotherm model (Fig. 1).

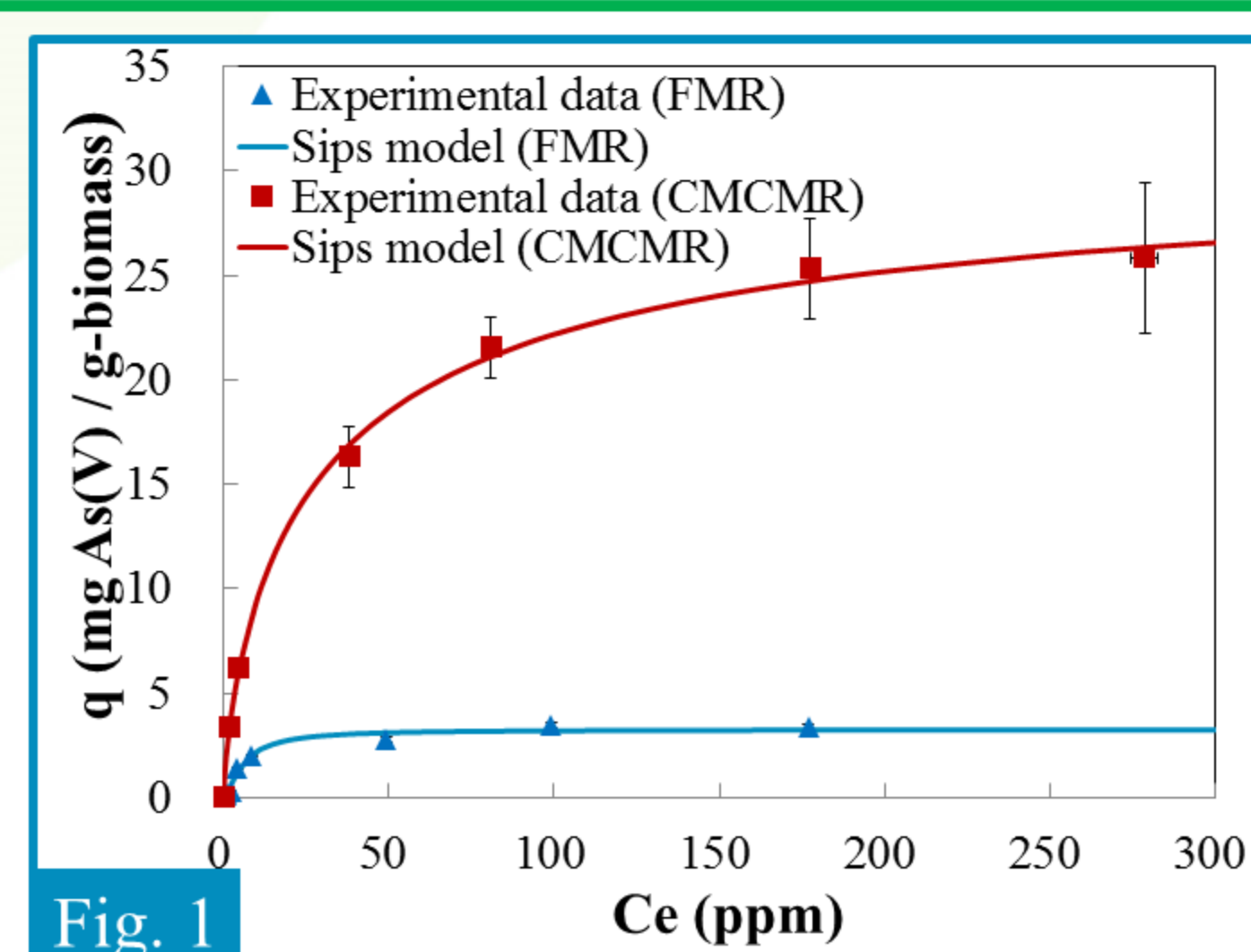


Fig. 1

References

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Effect of contact time

The As(V) biosorption kinetics of FMR and CMCMR increased gradually with contact time. The non-linear fractional power and pseudo-second order models could provide the best description of the kinetic data of FMR and CMCFMR, respectively (Fig. 2).

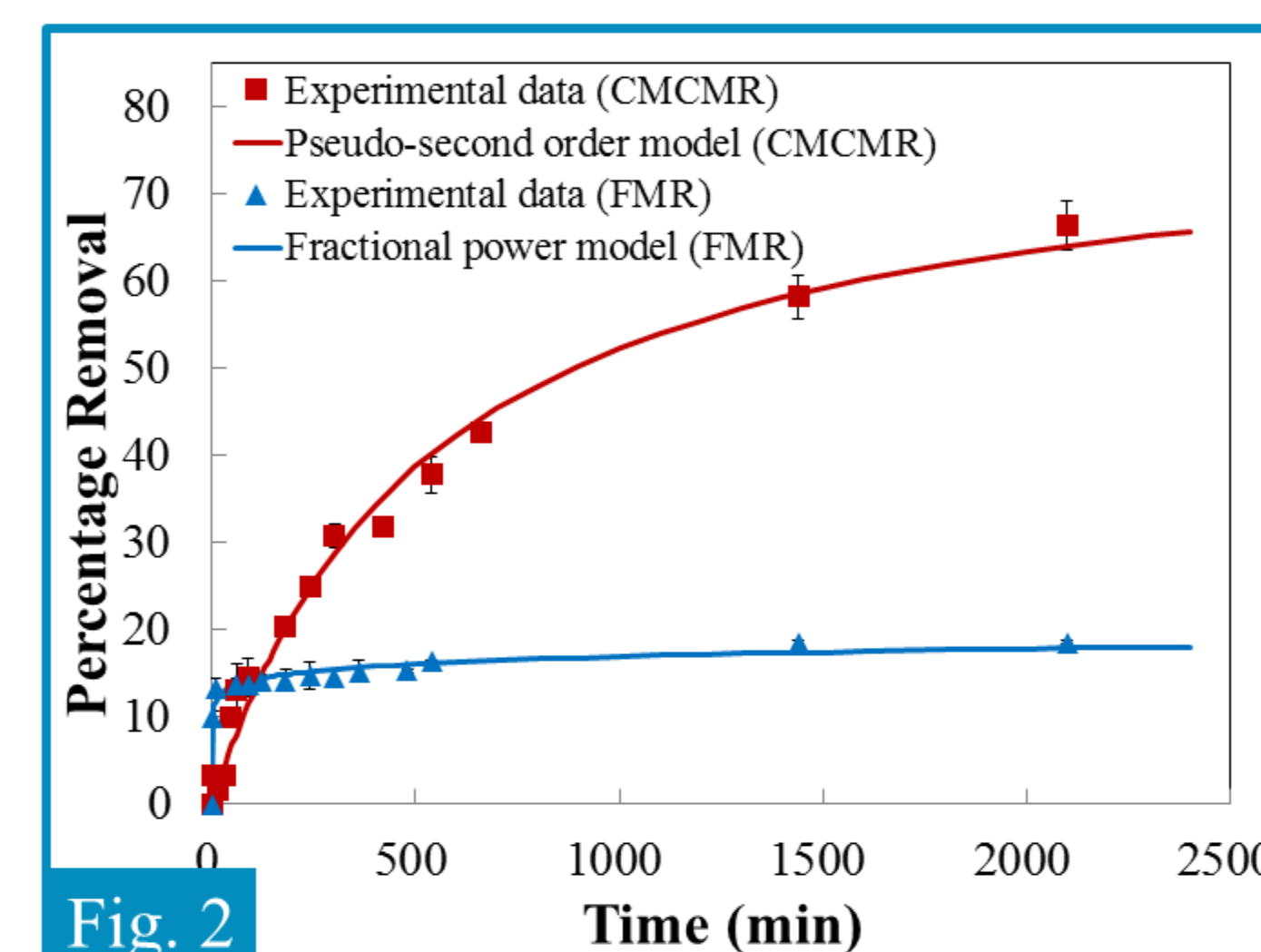


Fig. 2

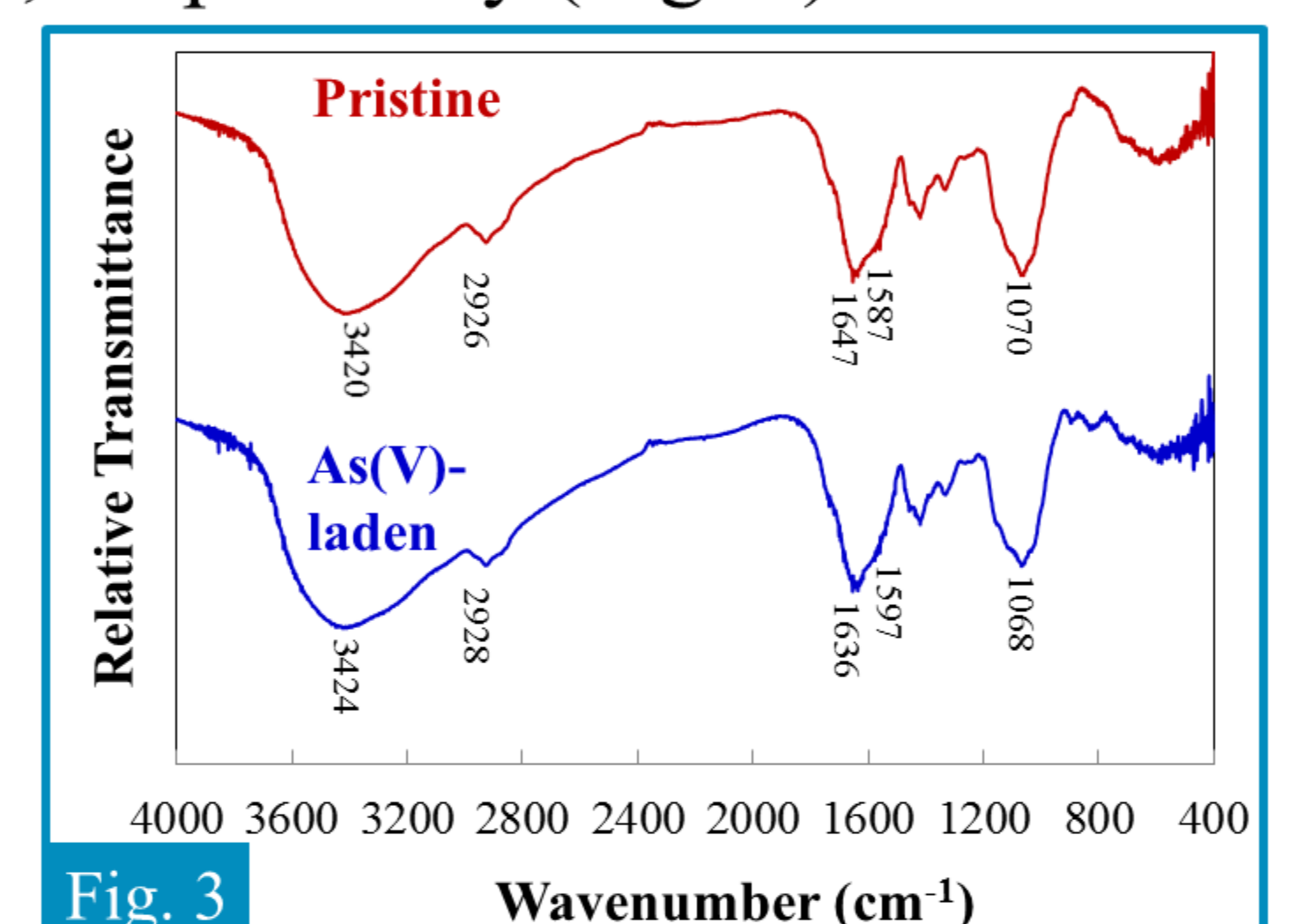


Fig. 3

FTIR, SEM-EDX & XPS analyses

The FTIR analyses of pristine and As(V)-laden CMCMR (Fig. 3) indicate that amine/amide and carboxyl groups could be involved in the As(V) biosorption. SEM images of FMR and CMCMR and EDX spectra of CMCMR before and after As(V) loading are illustrated in Fig. 4. As(V)-laden FMR was found swollen that could limit the availability of binding site for As(V) uptake. EDX analysis of CMCMR reveals the possible involvement of ion exchange between As(V) and Cl in the As(V) removal. The results of the high resolution C1s, O1s, N1s and Fe2p XPS spectra (Fig. 5) suggest the involvement of carboxyl, protonated amino groups and Fe(III) in the As(V) uptake process by CMCMR.

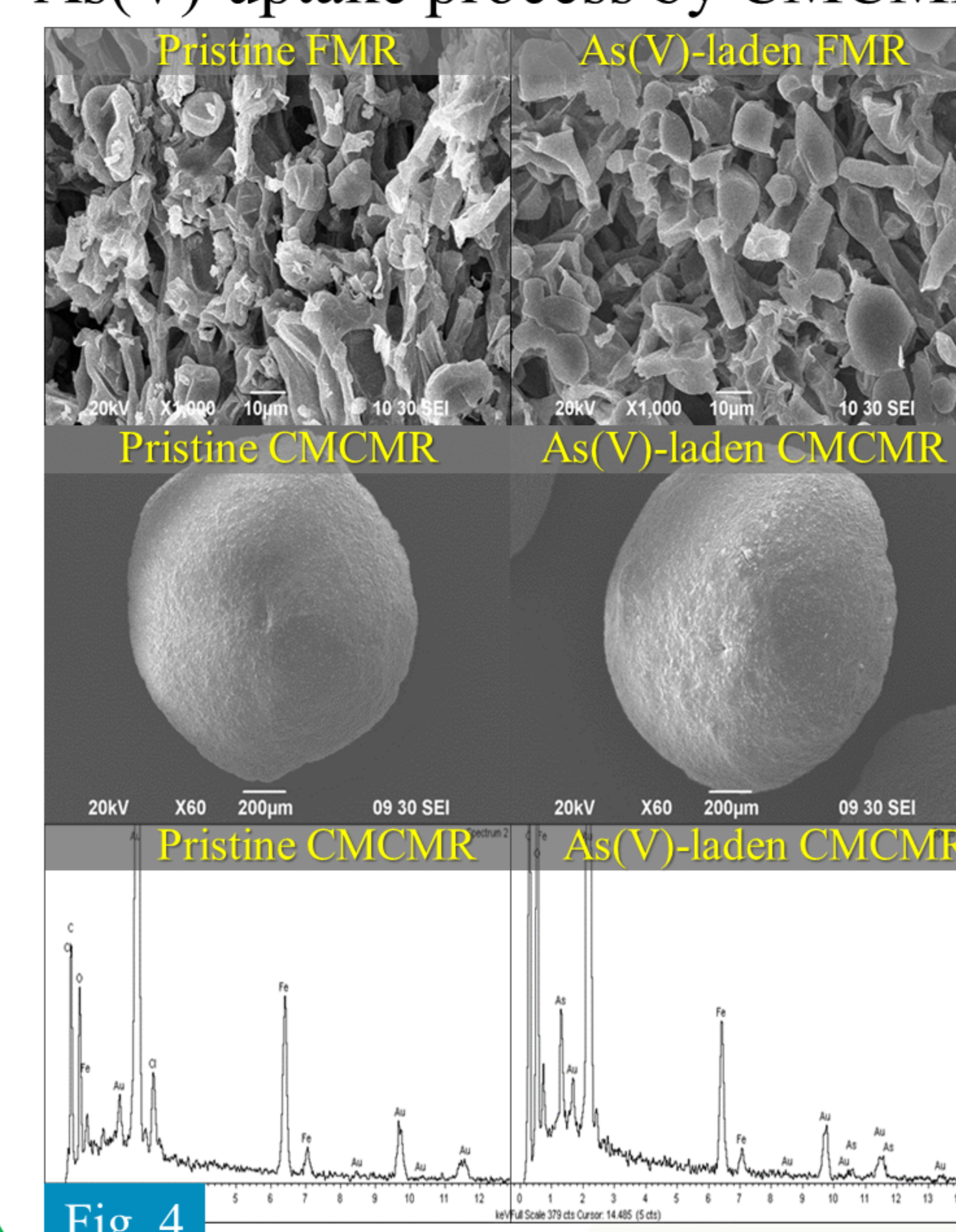


Fig. 4

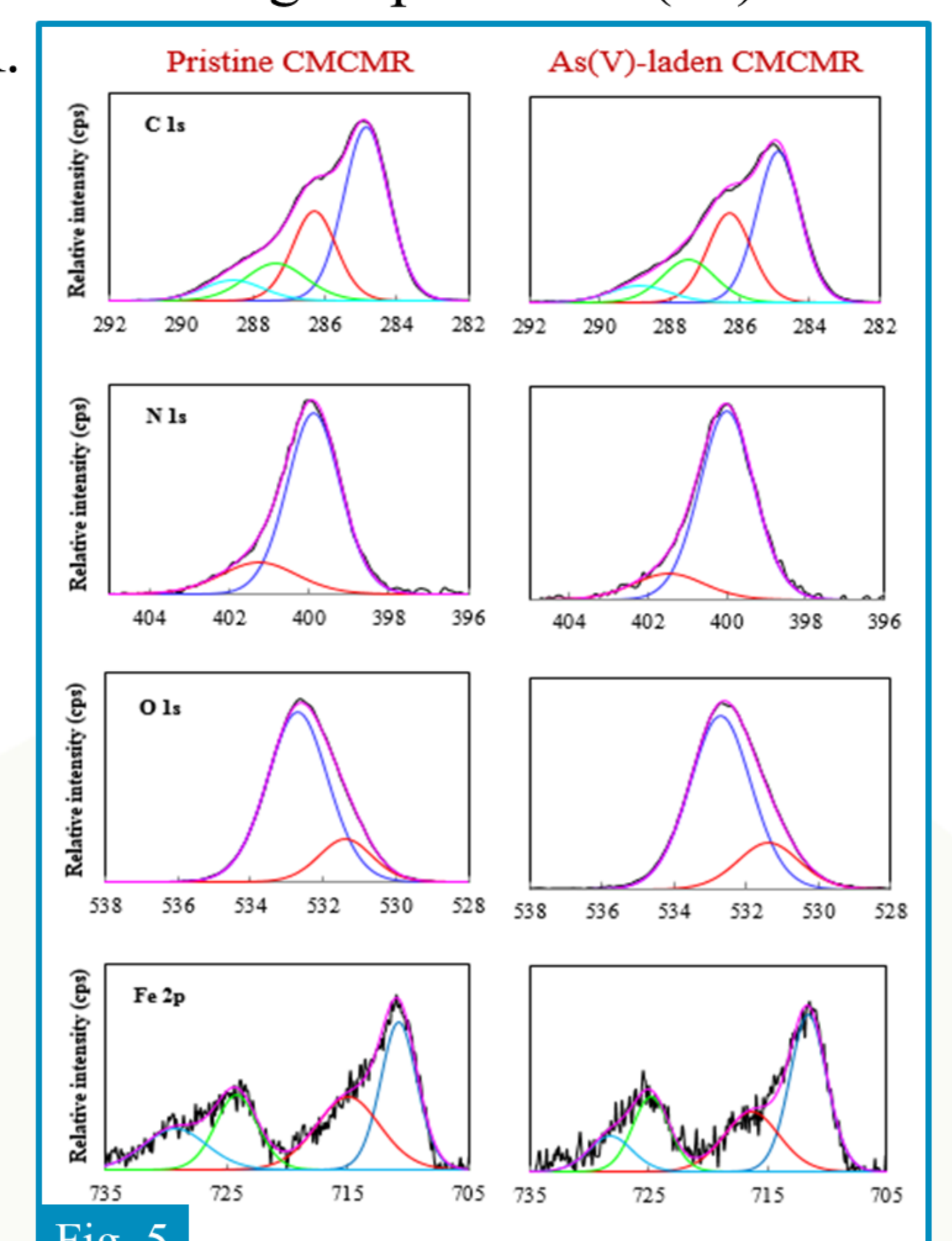


Fig. 5

Conclusions

Immobilization of *M. rouxii* in Fe-CMC significantly enhanced its As(V) removal ability. Spectroscopic analyses of CMCMR indicate the involvement of amino groups and possible occurrence of ion/ligand exchange in the As(V) removal process. Our results demonstrate that CMC-immobilized *M. rouxii* displays great potential for the treatment of As(V)-laden water.

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