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Ternary metal–organic framework composite with nanocellulose and deep eutectic solvent for the adsorptive removal of 3-MCPD esters

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Abstract
Removal of 3-monochloropropane-1,2-diol esters (3-MCPDEs) from edible oils is essential for better quality food consumption due to its detrimental effects on human health. Herein, we present a simple strategy for the in situ growth of a ternary metal–organic framework (Fe–Mn–MOF/N4) with nanocellulose (NC) extracted from almond shells using sulfuric acid (ASS) as a support for 3-MCPD adsorption in spiked extra virgin olive (EVO) oil. The sugar-based deep eutectic solvent (SDES) was also employed as co-solvent to enhance the active sites of the synthesized MOF, thereby increasing the adsorption capacity of the primary solid adsorbents, such as MOF and NC-ASS. The Fe–Mn–MOF/N4 achieved 85% removal of 3-MCPD under optimal conditions (6 h, 40 °C, 60 mg dose of Fe–Mn-MOF/N4, 1 g of NC-ASS, and 200 µL of SDES) via an indirect method. The adsorption performance, analyzed using Langmuir and Freundlich isotherm models, showed excellent adsorption capacity while maintaining the quality of EVO oil within acceptable limits after treatment. Importantly, Fe–Mn–MOF/N4 could be reused up to five times, with an adsorption efficiency of 48.3% after the final cycle, demonstrating its sustainability. However, further optimization is needed to prevent the gradual decline in adsorption efficiency and to meet the regulatory standards. This method offers a sustainable, effective solution for 3-MCPDE reduction, highlighting the potential of MOF-based materials to enhance food safety by reducing harmful contaminants in edible oils and food products. © The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2024.

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3-Monochloropropane-1,2-diol esters; Adsorption; Edible oil; Food safety; Metal organic frameworks; Olive oil

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