Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34944

Mechanistic understanding of mycotoxin removal by modified smectites: From zearalenone to emerging toxins - alternariol and enniatin B

JAKUB MATUSIK[1], KLAUDIA DZIEWIĄTKA[1], YOUJUN DENG[2], ANETA MATRAS[3], DOMINIKA BOROWSKA[3], PIOTR JEDZINIAK[3] AND MAŁGORZATA GBYLIK-SIKORSKA[3]

[1]AGH University of Krakow
[2]Texas A&M University
[3]National Veterinary Research Institute

This study evaluated the removal efficiency and mechanisms of three structurally diverse mycotoxins: zearalenone (ZEN), alternariol (AOH), and enniatin B (ENN B) by modified smectites under aqueous and simulated gastric fluid (GF). Cation exchange and/or calcination resulted in poor adsorption performance with the exception of ENN B, highlighting the limited affinity of unmodified smectites for largely hydrophobic ZEN and AOH molecules. In contrast, ENN B removal was enhanced by Mg(II) exchange followed by thermal treatment (300–500°C), which reduced layer charge, generated hydrophobic domains and Lewis acid sites. While hydrophobic interactions dominated, the ion–dipole forces and hydrogen-bonding likely also contributed.

In contrast, organic functionalization with amphiphilic modifiers markedly enhanced ZEN and AOH adsorption by promoting interlayer expansion and increasing hydrophobicity. Among the tested modifiers, hexadecyltrimethylammonium bromide (C16) consistently exhibited the highest removal efficiency driven by high organic loading correlated with the smectites' cation exchange capacity. The C16-modified smectites contained neutral C16 molecules, providing optimal structural conditions for efficient uptake of ZEN and AOH. The smectites modified with ethyl lauroyl arginate (LAE®) and cocamidopropyl betaine (CAPB) showed lower removal efficiencies due to reduced organic loading caused by steric effects. Vitamin B1-functionalized Na-rich smectite also demonstrated enhanced adsorption, attributed to effective Na^+ exchange and increased surface hydrophobization. Linear adsorption isotherms followed the Freundlich model, supporting a dominant nonequilibrium partitioning mechanism for the ZEN and AOH.

All organically modified materials maintained high adsorption under acidic conditions, whereas alkaline conditions reduced efficiency, except for the C16-modified smectites. Notably, the C16- and B1-modified smectites resisted competitive pepsin interactions in GF, unlike the LAE®- and CAPB-modified materials. In turn, the ENN B removal was heavily hampered in GF, regardless of the adsorbent used.

Importantly, adsorption efficiencies were independent of specific surface area, emphasizing the decisive role of smectite interlayer and surface chemistry as the key factor of efficient removal of ZEN, AOH, and ENN B. This emphasizes the need for rational design of smectite-based adsorbents for mycotoxin mitigation in aqueous media and subsequently animal feed.

This project was partially supported by the National Science Centre Poland, under a research project awarded by Decision No. 2021/43/B/ST10/00868.