

Intercalation of squalene into H^+ - and Al^{3+} -exchanged montmorillonite clays and releasing of squalene at simulated gastric conditions

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Squalene ($\text{C}_{30}\text{H}_{50}$) is a triterpene found abundantly in shark liver oil, in reasonable amounts in amaranth oil and olive oil, and to a lesser extent in other vegetable oils such as corn oil, sunflower oil and soybean oil and in microorganisms. Although squalene (SQ) has various beneficial effects including anticancer, antioxidant and anti-inflammatory properties, its use as a therapeutic drug is limited due to its low bioavailability owing to its lipophilic nature. Incorporation of squalene into the hydrophobic cavity of β -cyclodextrin (β -CD) can yield a composite with a hydrophilic outer coat which can then be intercalated into montmorillonite (MMT) clay's hydrophilic interlayer nanospace. MMT clays are layered aluminosilicates with expandable interlayer 1-2 nm space, having exchangeable cations between the layers. In this study, intercalation of squalene into cation-exchanged H^+ - and Al^{3+} -MMT ($\text{M}^{\text{n}+}$ -MMT) with and without the assistance of β -CD, and subsequent releasing of squalene from the clay composites at simulated gastric conditions (pH 1.2, 37 °C) were investigated. The cation-exchanged H^+ - and Al^{3+} -MMT were prepared by stirring purified Na^+ -MMT clay with aqueous HCl and AlCl_3 , respectively. $\text{M}^{\text{n}+}$ -MMT- β -CD-SQ composites were prepared by mixing SQ, β -CD and $\text{M}^{\text{n}+}$ -MMT according to three different procedures that differ from one another in the order of mixing the components. All the $\text{M}^{\text{n}+}$ -MMT clays and the $\text{M}^{\text{n}+}$ -MMT- β -CD-SQ clay composites were characterized by FTIR and X-ray diffraction techniques. The most effective method was mixing of SQ, β -CD and $\text{M}^{\text{n}+}$ -MMT together, which afforded more than 80% incorporation of SQ. In the absence of β -CD, SQ loading into Al^{3+} -MMT decreased to 66% while that into H^+ -MMT remained almost the same. Releasing studies conducted at simulated gastric conditions with time revealed gradual releasing of SQ, reaching 97% and 100% release from Al^{3+} -MMT- β -CD-SQ and H^+ -MMT- β -CD-SQ composites, respectively, after 6 h. Squalene-intercalation and -release were quantified using gas chromatography. In conclusion, SQ can be intercalated into cation-exchanged MMT clays and SQ can be slowly released from the clay composites at simulated gastric conditions.