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NOTES

ADSORPTION OF MELTED DRUGS ONTO SMECTITE

Key Words—Drug adsorption, Smectite.

Montmorillonite, a 2:1 clay mineral, is known to accommodate different organic substances within its interlayer space to form intercalation compounds, which have received much attention because of their stability and physicochemical properties. Its use as a drug carrier is widely studied, as the location of the drug molecules within the interlayer space of the clay may modify the suitability of some drugs for biological use (Grim 1962; Theng 1974; Grim and Güven 1978; Porubcan et al. 1979; Browne et al. 1980; Hermosín et al. 1981; White and Hem 1983; Forteza et al. 1989). Usually, intercalation is achieved by adsorption from aqueous solutions of the drug, but some authors have recently reported on alternative methods that are faster, cleaner and cheaper, such as mechanically grinding a mixture of the drug and the clay (Vicente et al. 1989; Ogawa et al. 1989, 1990a, 1990b, 1991). Bujdák and Slosiariková (1992) have reported intercalation of octadecylamine into montmorillonite by solid state reaction. Further intercalation was observed after melting of octadecylamine, but was followed with partial decomposition. We report intercalation of two different drugs, currently used as sunburn protectors, into the interlayer space of montmorillonite by melting, without any decomposition.

EXPERIMENTAL

A commercial sample from Fluka (Montmorillonite K-10, ref. 69866) was used for our experiments. The sample contained small amounts of illite and kaolinite, as identified by their X-ray diffraction (XRD) maxima at 9.81 Å for illite and 7.13 Å for kaolinite. We have used a commercial sample instead of a pure one, as the aim of our work is essentially to check the suitability of the material as a drug support, and this sample is cheap and abundant. The specific surface area, as determined by the single point method from a Micromeritics Flowsorb 2300 apparatus, was 245 m^2g^{-1}, and the exchange capacity was 86 meq/100 g. The sample was saturated with Na^+ by successive washings with aqueous NaCl at room temperature.

Two different drugs were intercalated by melting: phenyl salicylate (PS) and N-methyl 8-hydroxy quinoline methyl sulphate (NMHQMS). The first one was from Fluka, while NMHQMS was synthesized according to the method described by Faller et al. (1964). Both drugs are currently used to prevent sunburn and the effects of harmful radiation during soldering, by ultraviolet lamps, etc. While PS is a molecular substance, NMHQMS easily dissociates in aqueous solution. The corresponding cation is responsible for its light-shielding properties.

Adsorption was carried out by intimately mixing given amounts of drug and the smectite and heating slowly (1 °C/min) up to the melting point of the drug (43 °C for PS and 147 °C for NMHQMS). The temperature was maintained for 24 h. All of the process was carried out in open air. The relative amounts of drug and smectite to be mixed were 450 mg of drug/500 mg clay. The XRD patterns of the solids were recorded from a Philips PW-1730 apparatus using Nifiltered Cu Kα radiation (λ = 1.5405 Å). The FT-IR spectra were recorded from a Perkin Elmer FT1730 spectrometer, using the KBr pellet technique, averaging 50 scans with a nominal resolution of 4 cm^{-1}.

RESULTS AND DISCUSSION

We have previously reported the properties of compounds formed by grinding mixtures of smectite (Vicente et al. 1989) or sepiolite (del Hoyo et al. 1993) and NMHQMS. It was shown that the method leads to the same type of compounds as those obtained by following the conventional method of adsorption from aqueous solutions. However, the grinding process also leads to a loss of crystallinity because of the smaller size of the resulting particles.

The XRD patterns of the parent smectite and of the complexes formed after melting PS and NMHQMS onto the smectite are shown in Figure 1. The diagrams were not recorded following the oriented aggregate

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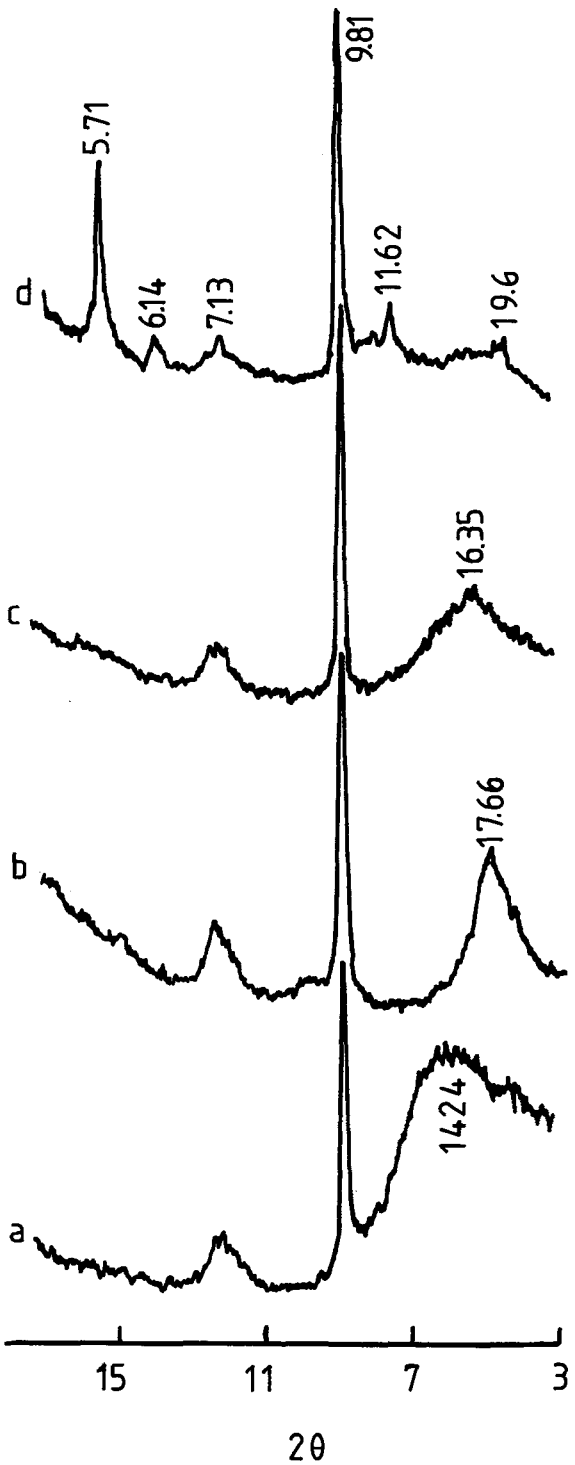

Figure 1. X-ray diffraction (XRD) pattern of: a) parent smectite; b) after swelling with glycerol; c) after melting N-methyl 8-hydroxy quinoline methyl sulphate (NMHQMS); and d) after melting phenyl salicylate (PS). Reflections are given in Å.

method, despite that it provides a better definition of the peaks corresponding to basal planes, in order to avoid any re-adsorption of the molecules in the interlayer space from the aqueous solution formed.

Intercalation of the organic molecules gives rise to a swelling of the clay structure, the basal spacing increasing from 14.24 Å for original smectite (Figure 1-a) to 16.35 Å for the NMHQMS-treated sample (Figure 1-c) and to 19.6 Å for the PS-treated one (Figure 1-d). Swelling with glycerol gave rise to a basal spacing of 17.66 Å (Figure 1-b). The sharp peak at 9.81 Å is due to illite, and that at 7.13 Å is due to kaolinite, both existing within the original smectite as impurities. The peaks at 11.62, 6.14 and 5.71 Å from the diagram of sample smectite-PS are originated by the drug as compared to the XRD diagram of the pure drug. For the smectite-NMHQMS sample, the position of the peak at 16.35 Å coincides with that reported by Vicente et al. (1989) for smectite-NMHQMS systems prepared by conventional adsorption from aqueous solutions and by joint grinding of the drug and the clay. These results indicate that while for PS, a molecular substance, intercalation takes place through substitution of water molecules within the interlayer space, NMHQMS dissociates and intercalation corresponds to cation exchange with interlayer Na^+ cations.

The FT-IR spectra of the samples have been recorded in order to check if melting has led to decomposition of the drugs. Bujdák and Slosiariková (1992) reported decomposition of the intercalated molecule when heating a montmorillonite-octadecylamine system at 75 °C. However, heating at a lower temperature did not lead to complete intercalation because of lack of melting of the organic molecule.

The FT-IR spectrum of the smectite-PS system coincided with the sum of the spectra corresponding to the pure compounds (Figure 2), indicating a weak, if any, interaction between both. Thus, characteristic bands of the drug are recorded at 1485 cm^{-1}, di-substituted ring, 1410 cm^{-1}, C-O stretching, and 1212 cm^{-1}, deformation of the phenyl OH group. These bands are recorded at the same positions as in the spectrum of PS.

On the contrary, some differences can be observed between the spectra of smectite and drug NMHQMS and the spectrum of the intercalation compound (Figure 3). The differences mainly consist as the absence of the intense bands due to the sulphate group at 1077, 833 and 754 cm^{-1}, although the first one could be included in the strong absorption due to the support. Thus, it should be concluded that while drug PS is adsorbed without any chemical change of its molecular state, only the cationic part of NMHQMS is adsorbed after dissociation.

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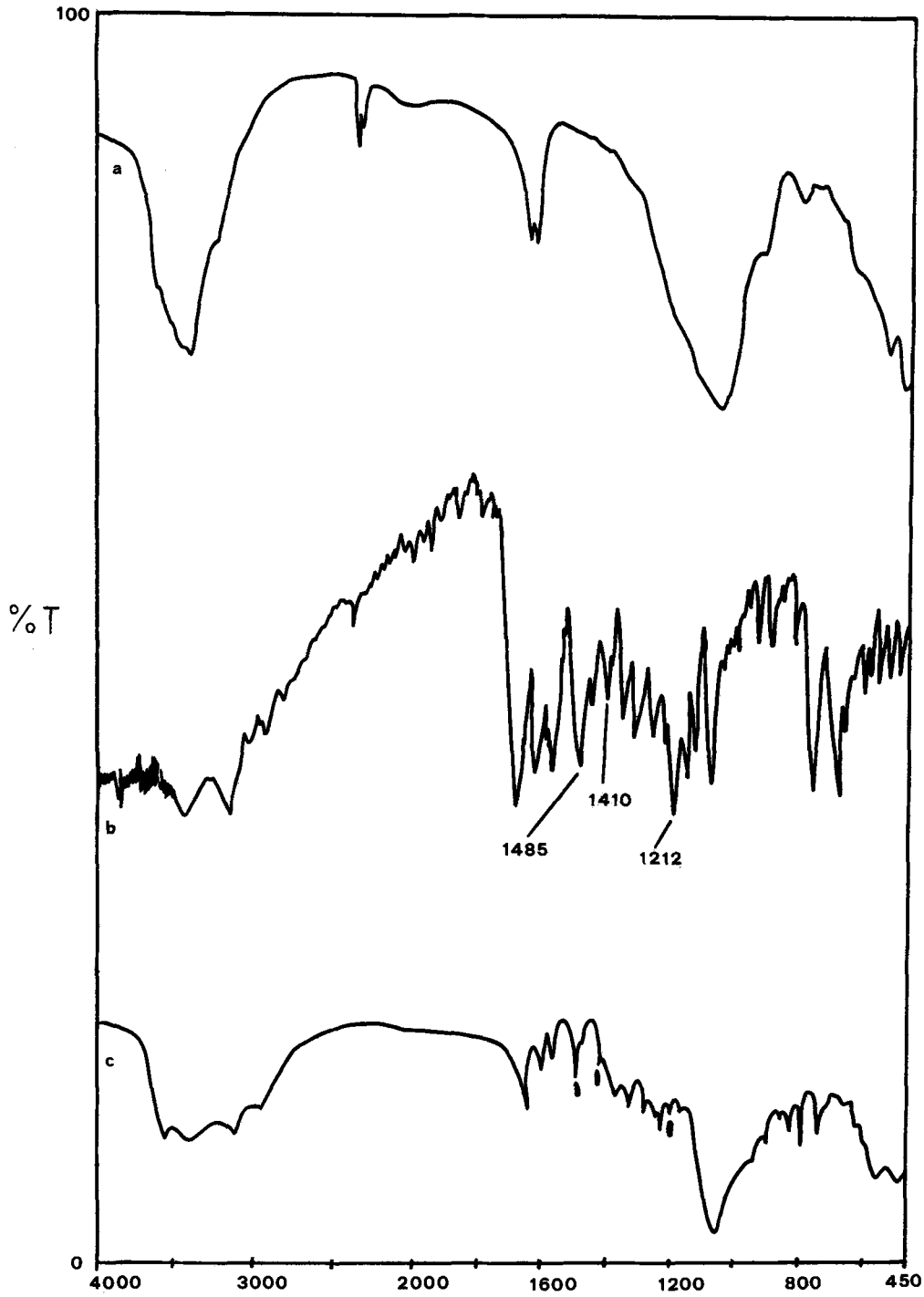

Figure 2. FT-IR spectra of: a) parent smectite; b) phenyl salicylate; and c) phenyl salicilate-smectite complex.

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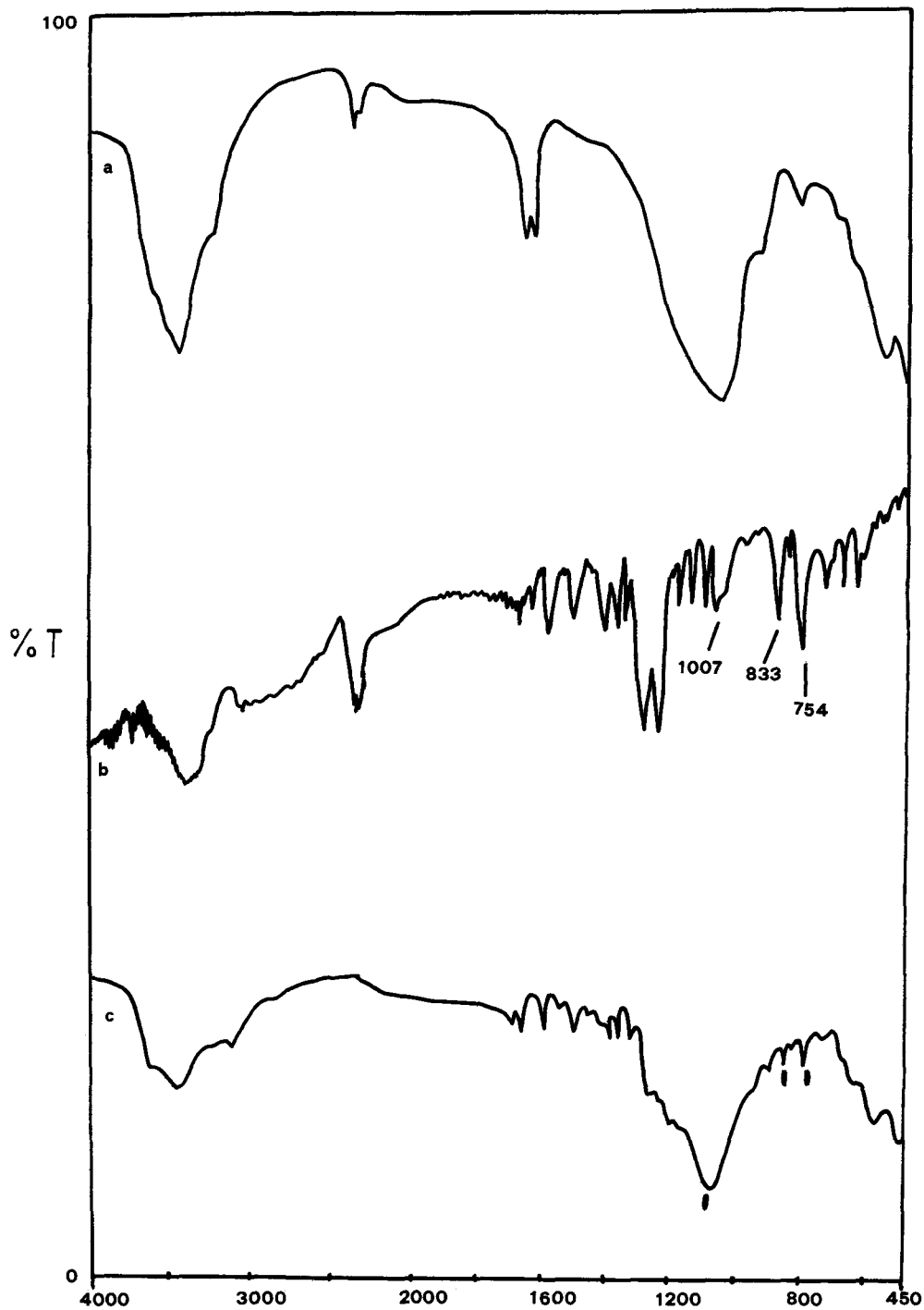

Figure 3. FT-IR spectra of: a) parent smectite; b) N-methyl 8-hydroxy quinoline methyl sulphate; and c) N-methyl 8-hydroxy quinoline methyl sulphate-smectite complex.

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The method we described possesses several advantages over the other two methods of adsorption from solutions and joint grinding that are reported widely within the literature. The present method allows incorporation of molecules insoluble in water (phenyl salicylate).

We conclude that heating an intimate mixture of the drug and the clay at the melting temperature of the drug leads to an easy intercalation. The method is faster and cleaner than intercalation from aqueous solution and avoids loss of crystallinity that happens when adsorption is carried out by grinding a mixture of the drug and the clay.

The ability of these systems for adsorption of ultraviolet light and their potential use as sunburn protectors are currently being studied at our laboratories.

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