Communications to the Editor

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SOME APPLICATIONS OF PHOTOACOUSTIC SPECTROSCOPY TO THE ANALYSIS OF PHARMACEUTICAL POWDERS

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Photoacoustic spectroscopy was used as a technique to measure the visible spectra of powdery pharmaceutical samples. It was demonstrated that methyl red is in acid-form in crystalline cellulose and in base-form in MgO. This study indicates that photoacoustic spectroscopy is very effective in the analysis of pharmaceutical powders.

KEYWORDS ——— photoacoustic spectroscopy; powdery sample; visible spectrum; methyl red; methaphyllin; brilliant blue FCF

Photoacoustic spectroscopy (PAS) is being observed with interest due to its convenience in measurement and sample preparation.[1-4] In this paper, we describe some applications of PAS to the analysis of pharmaceutical powders.

We produced our own single-beam photoacoustic spectrometer. The light source is a high-pressure 500-W xenon arc lamp (Ushio, UXL-500D) associated with a monochromator (Nikon, G250). The cell is made of brass and a microphone (Nippon Chemicon, EPM-100) is used as the detector. The modulation frequency of the light is 16 Hz. Carbon black (perfectly absorbing) is used as a reference material and the relative photoacoustic (PA) signal was calculated as reported by Monahan and Nolle.[5]

Brilliant blue FCF (BB) was used as a standard material for comparing PA and absorption spectra. Figure 1 shows the PA spectrum of a BB and CaF_2 mixture and the absorption spectrum of a BB aqueous solution. Note that the PA spectrum has almost the same pattern as the absorption spectrum. This indicates that PAS can be used with colored powdery samples.

Methyl red is a pH indicator with a pKa of 4.8 . One ml of 201 mg/l methyl red ethanol solution was added to some powders (1.0 g) and dried in an oven at 80°C. The PA spectra were recorded as shown in Fig. 2. Absorption spectra

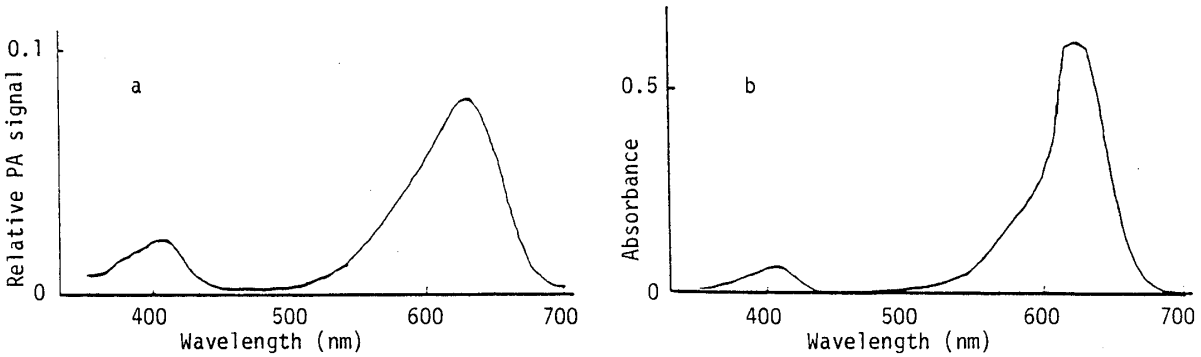

Fig. 1. Photoacoustic Spectrum (a) and Absorption Spectrum (b) of Brilliant Blue FCF (BB)
Concentration of BB: a, 0.1 mg/g of CaF_2; b, 4mg/l of distilled H_2O.

of methyl red aqueous solution in the pH range of 4-7 were measured to compare with the PA spectra (Fig.3). In samples with diluents of crystalline cellulose, of synthetic Al silicate and talc, the maximum PA signal was observed in the region of 500-520 nm. These PA spectrum patterns were simillar to solution absorption spectra at pH 4 and 5. On the other hand, when MgO or activated alumina was used as a diluent, the PA maximum occurred at 400 nm and this maximum peak position was the same as absorption spectra at pH 6 and 7. Machida et al. have investigated the structure of the acid and the base forms of methyl red, and reported that, at low pH, methyl red exists in acid form (quinoid-type) and at high pH, in basic form (azo-type).[6] The difference in PA spectra was attributed to different molecular structures. Consequently the surface of crystalline cellulose and talc appears to be in an acidic condition. Vorob'ev et al. studied the acid-base properties of some catalysts by diffuse reflection spectroscopy and reported that methyl red on aluminosilicate showed an absorption maximum at 540 nm, while with methyl red on Al_2O_3 it was 410 nm.[7] The results were explained in terms of the difference of the surface acid property of aluminosilicate and Al_2O_3. Photoacoustic spectra obtained here are nearly the same as the diffuse

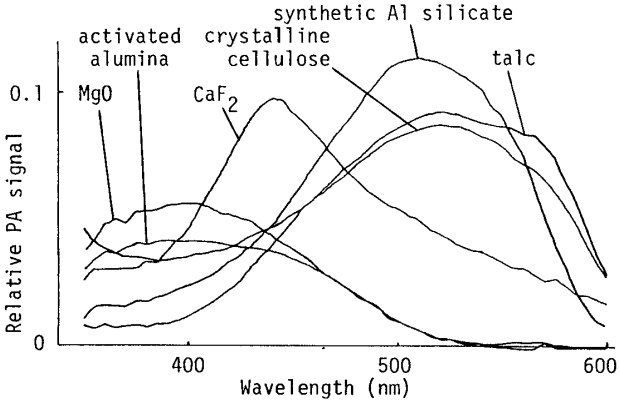

Fig. 2. Photoacoustic Spectra of Methyl Red with Various Powders

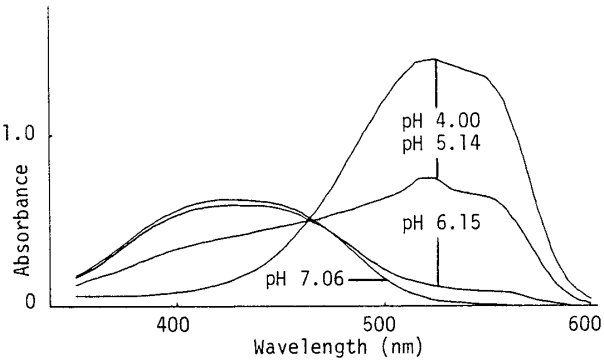

Fig. 3. Absorption Spectra of Methyl Red in Aqueous Solution

reflection spectra, therefore our method is reliable in the study of the acid properties of powders, and also is convenient for observing the state of the indicator.

Further, PAS is used for quantitative analysis. Methaphyllin (Eizai Co.) was diluted with lactose with a mortar and pestle. The methaphyllin concentration was 0.2-1.0%. After sieving the mixture (less than 63 μm), relative PA signals were measured at 402 nm. Ten replicate experiments were carried out for each sample. The linear relationship of the concentration of methaphyllin and the relative PA signal was as shown in Fig. 4. PAS is a reliable quantitative analytical technique in the range of proper concentration.

In conclusion, PAS is nondestructive and highly sensitivity for powder analysis. It is an effective technique for the analysis of pharmaceutical powders.

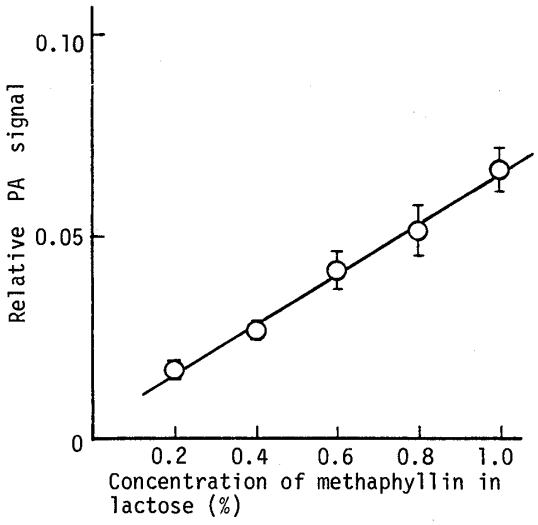

Fig. 4. Relationship between the Concentration and the Relative PA Signal

Each point represents the mean ± S.D. of ten experimental values.

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