2042
doi:10.1017/S1431927616011041

Microsc. Microanal. 22 (Suppl 3), 2016


# Characterization of Resultant Micro Chemical Test Crystalline Formations using Optical, Fourier Transform Infrared (FT-IR) and Raman Microscopies

Mark R. Witkowski Ph.D[1], John B. Crowe[1].

[1.] United States Food and Drug Administration (FDA), Forensic Chemistry Center (FCC), Cincinnati, U.S.A.

Micro chemical tests have been used to aid in the identification of materials and as rapid screening tools for microscopists and forensic chemists for decades[1-3]. It is generally understood in the microscopy community that these types of tests, with unique resultant crystalline formations, can be quite specific and used for material identification. However, some consider micro chemical tests as secondary identification tests[4], since many of the tests involve the same chemical reagent used for a variety of analytes. Many of these micro chemical tests are used at the FCC in the analysis of forensic evidence to rapidly determine the presence or absence of drugs and other organic and inorganic chemicals. These tests can be very useful in the characterization of dietary supplements, which consist of very complex mixtures. It can be argued that the need for micro chemical tests is becoming less important with the availability of very sensitive instrumental techniques such as mass spectrometry. However, these tests allow for very rapid separation of a heterogeneous mixture, provide sample matrix information and information on the crystallinity of a material. This is especially important for pharmaceuticals, as a difference in drug crystallinity can affect its bioavailability.

Optical microscopic techniques, specifically polarized light microscopy (PLM), are very effective at characterizing the crystalline forms generated by micro chemical tests. However, PLM is limited in its ability to provide specific chemical information of a material. Vibrational spectroscopic techniques such as Fourier transform Infrared (FT-IR) and Raman spectroscopies provide unique chemical information of a material, and can be used to determine a material's proper crystalline form. Because of their chemical specificity, vibrational spectroscopic techniques are considered primary identification tests[4]. The combination of PLM, vibrational spectroscopic techniques and micro chemical tests provides a very powerful way to characterize and identify materials. PLM, FT-IR and Raman techniques can be used to demonstrate that, although a single chemical reagent is being used to test for many analytes, the unique crystal formations generated are specific for a given analyte under examination. An example is the use of squaric acid to determine the presence of potassium or zinc cations. Figure 1 shows PLM images of crystal formations of potassium squarate and zinc squarate. Each squarate salt exhibits a different crystal structure and birefringence. Figure 2 is the Raman spectra of the crystals from Figure 1. The spectral differences, noted with arrows, include Raman peaks present in the potassium squarate which are not observed in the zinc squarate spectrum. Additionally, the doublet observed between 600-800 $cm^{-1}$ for potassium squarate is shifted towards the Raleigh line compared to the same doublet for zinc squarate. The PLM examination of the crystals formed clearly differentiates between potassium and zinc based on their different crystal formations. The presence of different Raman bands in potassium squarate spectrum shows potassium is reacting differently to squaric acid than the zinc. Based on the PLM and Raman data, the two different cations react to the same reagent in two different manners forming two unique squaric acid salts. The techniques PLM, FT-IR and Raman can be used to validate a given micro chemical test for a set of analytes by helping to understand the chemical processes which lead to unique crystalline formation.

The FCC is currently working to establish a library of information, which includes optical and spectral information, used to characterize resultant micro chemical tests. This paper will present examples of optical and spectral data collected for several different micro chemical tests for a variety of analytes and their application to forensic case work

References:

[1] Behrens, H., 1894, A Manual of Microchemical Analysis, MacMillan and Co., London and New York.
[2] Stephenson, Charles H., 1921, Some Microchemical Tests for Alkaloids, J.B. Lippincott Company, Philadelphia and London.
[3] Fulton, Charles C., 1969, Modern Microcrystal Tests for Drugs, Wiley-Interscience, New York, NY.
[4] Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) Recommendations Version 7.0, 2014 August-14.

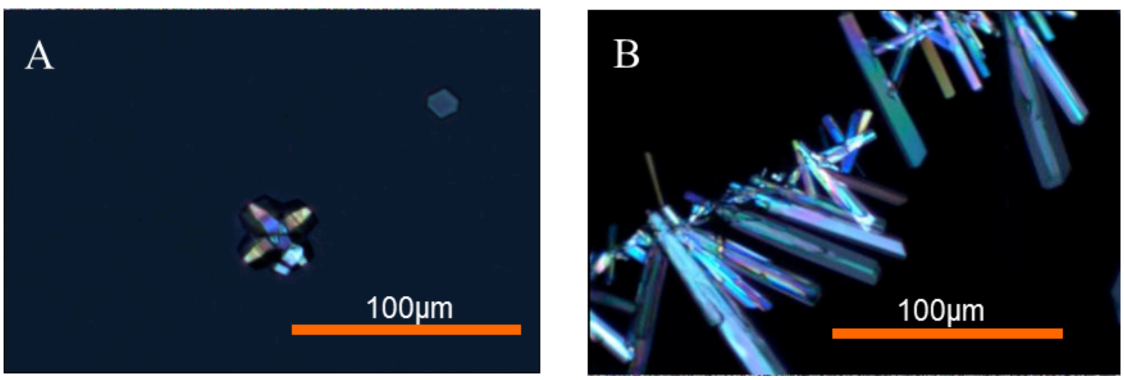


**Figure 1:** (A) potassium squarate crystal; (B) zinc squarate crystals.

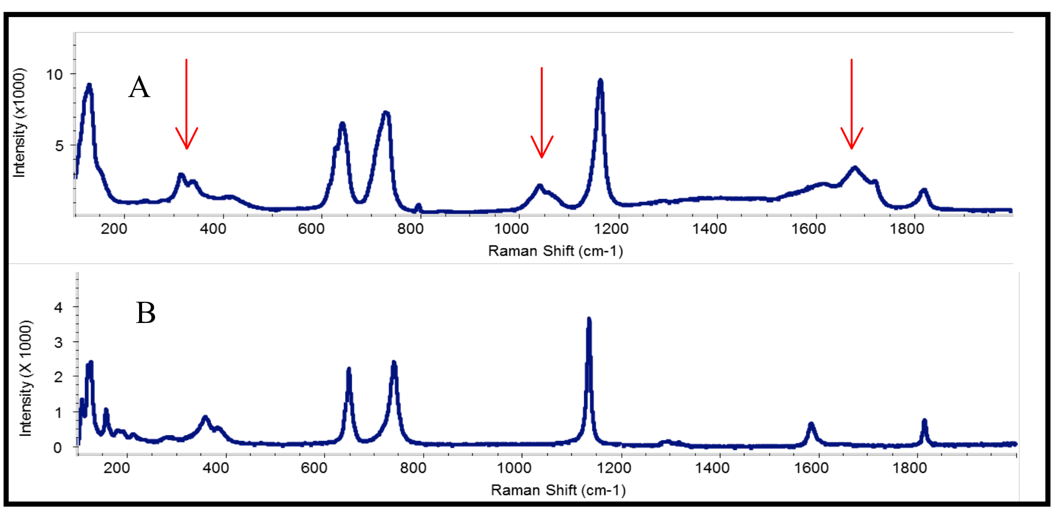


**Figure 2:** (A) Raman spectrum of potassium squarate crystal; (B) Raman spectrum of zinc squarate crystal.

https://doi.org/10.1017/S1431927616011041 Published online by Cambridge University Press