

Automated Analysis of Kidney Stones

Composition of kidney stones is relatively well known. Their main components include calcium oxalate, various calcium phosphates, uric acid and magnesium ammonium phosphate (MAP). These will identify the vast majority of stones. A few others are useful to know as well. Organic constituents (like cystine, cholesterol, bile salts, hemoglobin and protein); and stone-forming drugs (triamterene, indinavir, the sulfas, opheridine). The greatest challenge is identifying mixtures, especially when protein is present. Composition of the stone and the sequence of the deposited layers provide important diagnostics information.



Fig.1 Bladder and kidney stones. Analysis of kidney stones by chemical means is a laborious method which

requires a relatively large sample. Infrared (IR) dispersive spectroscopy greatly improved this process, but it was still fairly slow and used mainly for research. With the advent of computer technology and the introduction of Fourier transform infrared spectroscopy (FTIR) to the clinical laboratory, sensitivity of the measurements has been greatly improved and the analytical time shortened.

The most common IR sampling technique has been the KBr disk method. This process required grinding a small (1-6 mg) portion of the calculus with a measured amount of KBr, then compressing that into a pellet to be analyzed by IR.

When ARUP began doing calculi analysis around 1985, stone volume averaged 10 per week, done by two technologists who also did many other departmental tests. Last year (1996), the average sample volume increased to more than 50 each day, six days per week, while personnel had only increased to three technologists who were also responsible for performing other complicated and time consuming tests. Recent addition of an assistant responsible for making KBr pellets improved the situation slightly, but did not resolve all the problems. It was obvious that we needed to look for other solutions and streamline the analytical process.



Fig. 2 AutoDiff with the Motor Control Unit

The AutoDiff accessory is mounted in the FTIR spectrometer. The FTIR is set to 8 cm⁻¹ resolution and 32 scans. The spectra are collected from 4000 to 400 cm⁻¹ (the same range which is traditionally used by transmittance methods). The achieved time savings are substantial. By KBr pellet method, it took about 3 hours to get 50 samples from container to pellet, and about 2 hours to scan and print data for all of them. With the automated diffuse reflectance accessory, it takes about 2 hours to get a run of 50 samples from container to a sampling cup including

describing, weighing, crushing, separating layers and/or colors, as well as mixing the samples); then, it takes about 1 hour to scan and print out the results.

Our search concentrated on diffuse reflectance - a fairly promising technique, where the light reflected from powder-sample mix is analyzed directly instead of being transmitted through a pellet. Going to diffuse reflectance eliminated the whole step of making a pellet. In addition, this technique offered us the ability to fully automate collection of spectra, data analysis and processing steps. The PIKE

Technologies AutoDiff with the AutoPRO software, further saved waiting for each sample to be scanned. The new process allowed us to prepare a 60 sample run, then walk away while the FTIR scanned and printed results.

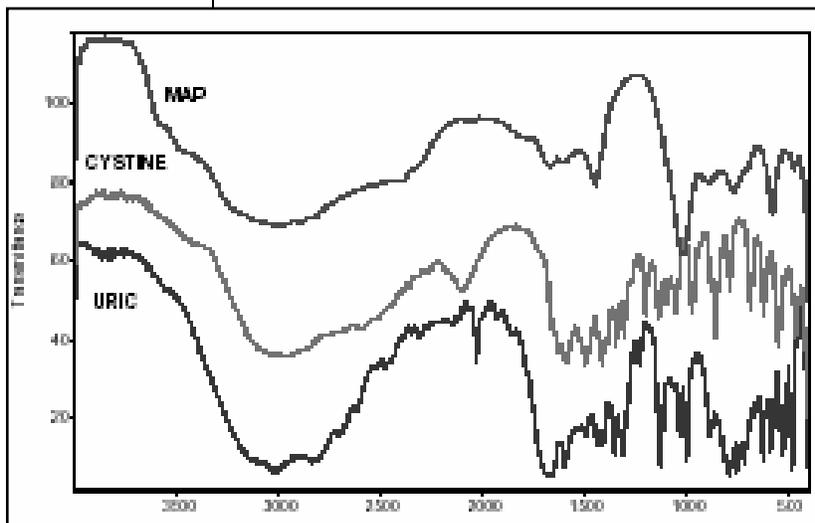


Fig. 3 Spectra of MAP, Uric Acid and Cysteine

Thus there is a time saving of 2 hours by eliminating both pressing the KBr pellets and the individual scan-and-print process for up to 50 samples.

Our next challenge is to expand the number of definable components in kidney stones. (At this point, some of them are not consistent with calculi

composition and are not considered medically important. However, additional studies may prove otherwise and may lead to better diagnostic information). We also would like to build our own library of identified spectra and automate our data comparison and identification programs.

This article has been written and printed with permission of Teri Wojcik of ARUP. Teri is responsible for calculi analysis in the Catecholamine and Vitamins Department. ARUP is an isotopic laboratory located in Salt Lake City, Utah. Within the Metabolics Department, about 1600 calculi are analyzed each month.