

Quantification of Urea in Ethanol by Raman Spectroscopy

Urea is widely employed as a nitrogen-release fertilizer with more than 90% of urea production destined for agricultural applications[1]. Urea is also known to form complexes with fatty acids[2], which have been employed for separation of complex mixtures and purification processes[3]. In this

application note, we present the quantification of the concentration of urea in ethanol by Raman Spectroscopy and show how this method can be employed for determining the percentage of urea in a solid inclusion compound with stearic acid[4].

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EXPERIMENTAL

Chemicals: Urea (Aldrich, >99%); Stearic acid (SA) (Aldrich, >95%); Ethanol (Soria)

Instrument: i-Raman® Plus 785S

Stock solutions of urea (0.0420 gr/gr ethanol) and SA (0.04126 gr/gr ethanol) were prepared. Standard solutions were prepared by mixing these stock solutions in different proportions in order to obtain urea concentrations between 0 and 0.042 gr/gr ethanol and keeping the total mass concentration

(urea + SA) approximately constant. Raman spectra of 0.5 mL of each solution in aluminum containers were measured employing a 785 nm laser (power: 30%, ~ 90 mW) and 5000 msec of acquisition time (20 repetitions). No effects of heating or evaporation were observed. Spectra of the standard solutions that were background corrected employing the BWSpec® software are shown in **Figure 1**.



Figure 1. Dark-subtracted baseline-corrected Raman spectra of the standard solutions of urea and SA in ethanol.

Spectra were normalized by employing the intensity of the ethanol band at $1049\text{--}1050\text{ cm}^{-1}$. Normalized spectra (**Figure 2**) clearly show that the only appreciable change due to the increment in relative urea concentration occurs at the band at $996\text{--}997\text{ cm}^{-1}$, which is attributed to urea. This band corresponds to the symmetric C-N stretching[5] that is experimentally and theoretically reported at about 1010 cm^{-1} for the solid urea,[6] but shifts to lower wavenumbers in solution.[5,7]

For quantification purposes, spectra were deconvoluted, fitting the experimental results in the region $950\text{--}1200\text{ cm}^{-1}$ by 4 Lorentzian functions. These curve fitting results are shown in **Figure 3** for some of the standard solutions.

The ratio of the intensities of the fitted peaks assigned to urea at 996 cm^{-1} (peak 1, a_1) and ethanol at 1049 cm^{-1} (peak 2, a_2) was employed as the analytical

parameters. The dependence of this ratio on the urea concentration of the samples is presented in **Figure 4**. The calibration curve plotted in this figure shows a good linear behavior which indicates this parameter could be employed for urea quantification.

For the determination of the urea content of real samples containing both urea and SA, the solid sample was dissolved in ethanol (0.04299 gr/gr ethanol) and Raman spectra were recorded in the same conditions. From the values of the ratio a_1/a_2 for this sample, obtained by fitting of the peaks at 996 and 1049 cm^{-1} (**Figure 5**), the urea concentration of the solution was determined to be $0.03274\text{ gr urea /gr ethanol}$. Thus, the urea content of the sample resulted to be $76\% \text{ w/w}$. This value is consistent with other reported values for the inclusion compounds formed by stearic acid and urea (ca. 75%).[2,4]



Fig.2: Normalized spectra of the standard solutions of urea + SA in ethanol. (A) Complete spectra (B) Analyzed region.



Figure 3. Fitting of the Raman spectra in the region 950-1200 cm⁻¹. Urea 30, Urea 60 and Urea 100 mean solutions 0.0123, 0.0248 and 0.0413 gr urea/gr ethanol respectively.

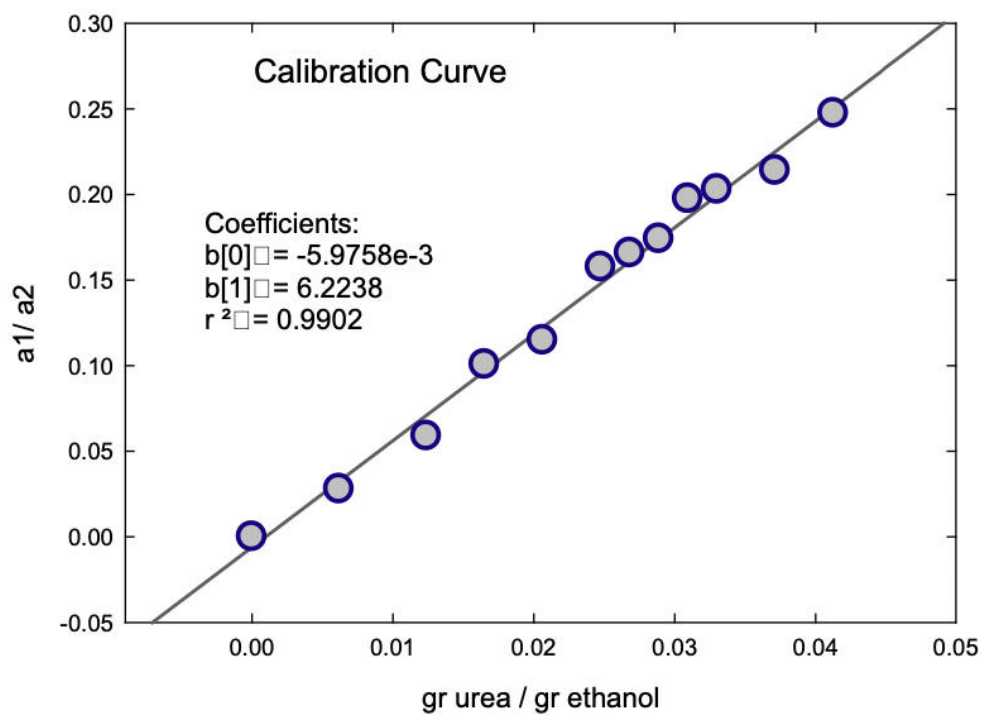


Figure 4. Calibration curve for the urea quantification in ethanol. Ratio of the intensities of the fitted bands of urea (a_1) and ethanol (a_2) as a function of the urea content of the standard solutions.

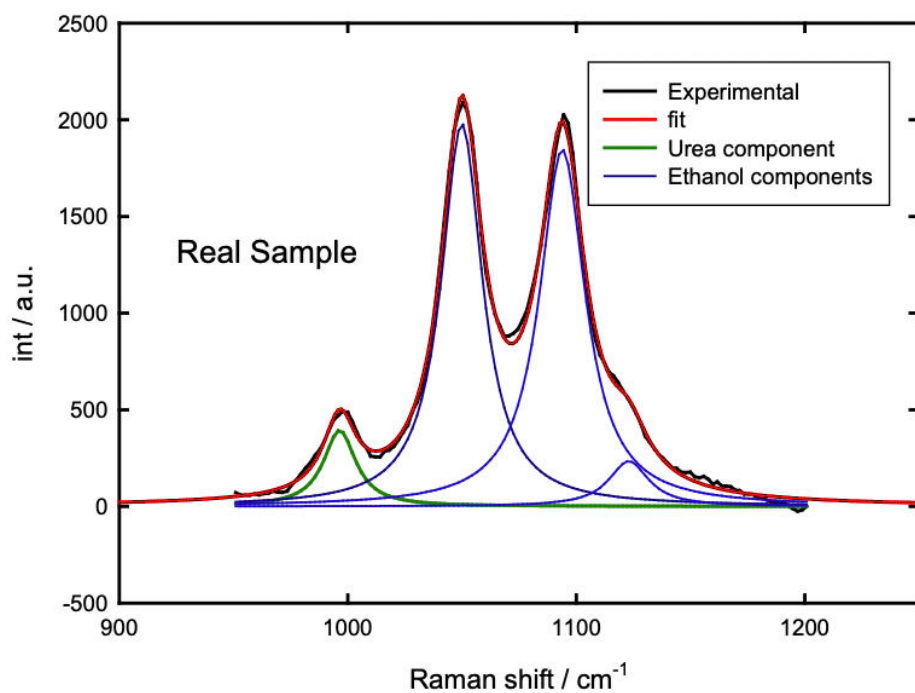


Figure 5. Fitting of the sample spectrum.

We presented a simple method for quantification of urea concentration in ethanolic solutions by Raman spectroscopy. The calibration curve presents good linearity in the concentration range analyzed (up to 0.042 gr urea / gr ethanol). The presence of stearic

acid in the samples does not modify appreciably the Raman spectra (at least up to 0.042 gr / gr ethanol), so this method allows the quantification of urea in solid binary samples containing both urea and stearic acid.

Related application notes

Choosing the Most Suitable Laser Wavelength

Quantification of methanol in contaminated spirits with Raman

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CONFIGURATION



i-Raman Plus 785S Portable Raman Spectrometer

The i-Raman® Plus 785S is part of our award-winning series of i-Raman portable Raman spectrometers powered by our innovative intelligent spectrometer technology. Using a high-quantum-efficiency CCD array detector with TE cooling and high dynamic range, this portable Raman spectrometer delivers excellent performance with low noise, even at integration times of up to 30 minutes, making it possible to measure weak Raman signals.

The i-Raman Plus 785S features the unique combination of wide spectral range and high resolution with configurations which allow measurements from 65 cm^{-1} to $3,350\text{ cm}^{-1}$. The system's small footprint, lightweight design, and low power consumption ensure research-grade Raman analysis capabilities at any location. The i-Raman Plus is equipped with a fiber probe for easy sampling, and can be used with a cuvette holder, a video microscope, an XYZ positioning stage with a probe holder, as well as our proprietary BWIQ® multivariate analysis software and BWID® identification software. With the i-Raman Plus, you always have a high precision Raman solution for qualitative and quantitative analysis.



Raman Cuvette Holder for 9.5 mm measurement probe

The BCR100A Raman cuvette holder allows you to easily measure Raman spectrum of liquids and powders by attaching a Raman probe to the holder. This accessory part uses an internal mirror with a three-point precision locking mechanism for unmatched reproducibility, thereby increasing the Raman signal up to 3x higher than conventional cuvette holders. It is designed so that the probe shaft does not directly contact the cuvette and includes a light trap to reduce background fluorescence. The BCR100A is available in model versions for probes with a diameter of 9.5 mm or 12 mm and can be used with any standard cuvette of 12.5 mm x 12.5 mm outer diameter (1 cm path length) for sampling liquids or powders.