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Research area: Process aims

Process measuring and control technology

Key words:

Raman spectroscopy, chemical imaging, paper analysis

TITLE:

Application of Raman Microscopy to Paper Analysis

Background/Problem area

With a few exceptions, paper is a product with a highly complex structure. Apart from fibrous materials, it contains a multitude of different components such as fillers, pigments, sizing and wet strength agents in addition to other chemical additives. The resulting paper properties depend strongly on the penetration and its consequent cross-sectional distribution (z-direction) of the additives in the paper sheet. Therefore, it is important to know the z-distribution of these substances in paper and paper board. However, analytical methods investigating the structure and composition of paper in z-direction have been lagging behind surface-analytical methods (x-y direction) to this day. Measurements in z-direction continue to present a major challenge regarding both local resolution and material specificity.

Raman spectroscopy offers new opportunities to analyse the z-distribution of substances in paper, making it possible to selectively detect organic and inorganic chemical compounds. The use of an excitation laser and an optical microscope provides for a very high spatial resolution of up to 1 µm. Paper samples can be measured directly, i.e. there is no need for lengthy or complicated preparation procedures. To study the distribution of substances, spectra are acquired point by point across the entire cross-section of the paper. The data collected in the scanned area can then be used to generate spectral images and distribution curves.

In addition, Raman spectroscopy is particularly suitable for the spectroscopic analysis of paper because the numerous OH groups present in cellulose give no signals in the Raman spectra. Therefore, unlike infrared and near infrared spectra, the Raman spectrum shows many characteristic vibration bands of the other paper components which can then be evaluated.

Objectives/Research results

The objective of the research project was the development of Raman Chemical Imaging measuring methods for paper analysis. The developed measuring and analysis methods allow the detection and identification of chemical substances in the paper cross-section and the evaluation of their distribution with a spatial resolution of up to 1 µm. The Raman Imaging analysis tools are part of the multispectral image analysis system DOMAS*multispec* by PTS.
The following results have been achieved:

- Development of measuring and analysis methods for Raman imaging measurements on paper
- Development of a spectral imaging software for the analysis of Raman imaging and other data, e.g. NIR imaging data
- Development of two standard analysis methods for
  - Detection and identification of individual substance layers in a multilayer system
  - Distribution analysis of paper component along the paper cross-section
- The developed measuring and analysis methods have been tested and demonstrated on different paper systems

The results of the project have been presented, for example, at the 26th PTS Streicherei Symposium in Munich from 16 to 17 September 2013 and at the XXIV. International Conference on Raman Spectroscopy in Jena from 10 to 15 August 2014.

Application/Economic benefits

The use of the Raman imaging technique for the micro analysis of the paper cross-section offers new promising possibilities to investigate the distribution of chemical particles and components in paper and to evaluate coatings. Until now, Raman spectroscopy has mostly been used for product control in the pharmaceutical and polymer industry. Applications in the paper industry still have to be explored and developed.

Raman imaging represents a major enhancement to the capabilities of other methods that were used to analyse paper cross-sections until now, especially Scanning Electron Microscopy (SEM). Raman spectroscopy adds to SEM the chemical information. The use of this information will be the key to the understanding of the bulk chemical and physical properties of paper products and consequently how these parameters influence their intended functionality.

Period of time: 01.02.2013 – 31.01.2015

Remarks

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