Application Note AN-RS-008

利用拉曼光谱鉴定单体

Monitor the polymerization process from monomer to polymer

Polymers are comprised of macromolecules that are in turn made of numerous identical or similar structural units, referred to as monomers. The number of monomers, including additives or inhibitors such as benzoquinone – used to endow the polymers with specific properties – is enormous.

All polymer manufacturers use the same monomers and can profit from a quick raw material check before feeding them into the polymerization process. Raman spectroscopy provides a nondestructive, in-situ, real-time analytical method to monitor the polymerization process by tracking monomer consumption and polymer formation. Ultimately, Raman spectroscopy is a convenient and efficient tool for various industries related to the polymer sector.

INTRODUCTION

This Application Note demonstrates the convenient identification of monomers within seconds using Raman spectroscopy. Monomers such as styrene, various alkyl methacrylates, vinyl acetate, ethylene glycol, phenol, terephthalic acid, and urea, as well as additives or inhibitors like benzoquinone, can be identified rapidly and unambiguously.

A quick demonstration of the distinct spectra of different monomers and their respective polymer leads to an in-depth look at the polymerization reaction of Bakelite.

EXPERIMENTAL

Raman spectroscopy is a simple point-and-shoot nondestructive analysis technique that allows for fast and safe analysis with no sample preparation. In some cases, samples can even be analyzed in their original packaging.

A handheld 785 nm Raman device, featuring an automated workflow and Orbital Raster Scanning (ORSTM), was used to collect basic monomer spectra.

The polymerization reaction of Bakelite was safely monitored by placing a laboratory Raman fiber-optic probe against the wall of a beaker containing the reactants, allowing real-time evaluation as the reaction progressed.

MONOMER SPECTRA

Figure 1 contains overlaid spectra of different monomers (and benzoquinone), demonstrating that Raman is both sensitive and high specific—it is very easy to distinguish the spectra of different materials.

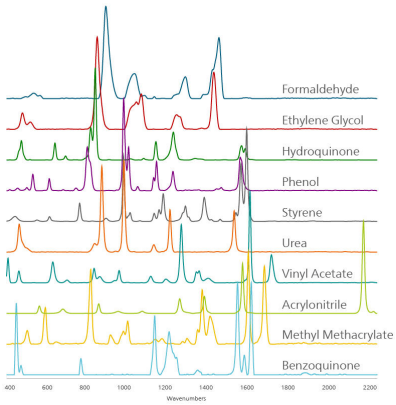

Figure 1. Overlay of Raman spectra from the analyzed monomers and benzoquinone.

MONOMERS AND POLYMERS

Monomers bind together to form polymers during the polymerization process. Real-time monitoring of the polymerization reaction with Raman spectroscopy is a powerful way to optimize and control the process and the resulting product. It is Raman's specificity that permits monomers to be easily distinguished from their respective polymers. Figure 2 illustrates the spectral differences between polymer starting materials and products.

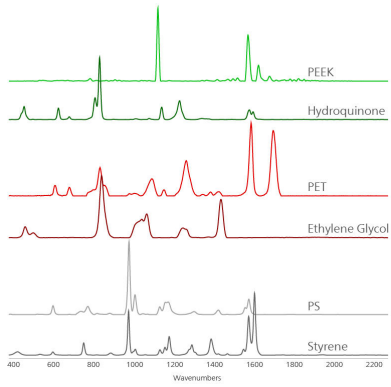

Figure 2. Overlay of Raman spectra from monomers with their respective polymers, including polyether ether ketone (PEEK), polyethylene terephthalate (PET), and polystyrene (PS).

POLYMERIZATION MONITORING WITH RAMAN

Bakelite is a thermosetting plastic created through the polymerization of phenol and formaldehyde. Figure 3 shows how the Raman peaks of phenol diminish as it reacts with formaldehyde to form a cross-linked polymer, while new peaks emerge due to changes in the vibrational environment. High Raman shift regions permit the observation of changes in the C-H stretching vibrations of phenol (2000–4500 cm1), providing insight into this reaction.

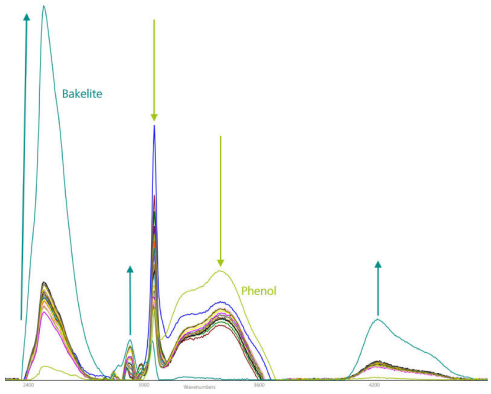

Figure 3. Evolution of Raman bands for phenol and Bakelite during the polymerization reaction.

CONCLUSION

Real-time, on-site analysis using Raman spectroscopy enables polymer manufacturers to maintain product integrity through quality checks at every stage, from raw materials to final products. This ensures consistent quality, optimizes efficiency, and drives innovation in polymer manufacturing.

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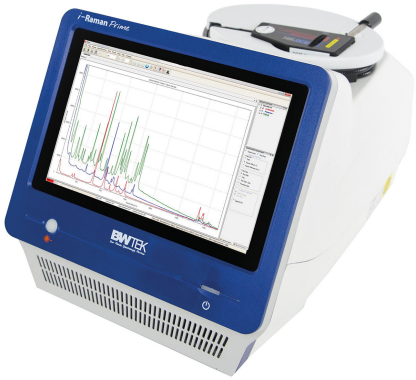
CONFIGURATION

MIRA P Advanced

瑞士万通快速拉曼分析仪 (MIRA) P 是一款性能强大的手持式拉曼光谱仪,可用于各种材料的快速无损测定和验证,例如药物有效成分和赋形剂。MIRA P 小而坚固,配备了瑞士万通的ORS技术。MIRA P 符合 FDA 联邦法规 21 章第 11 款的规定

。Advanced Package 包含一个附加透镜,可用它直接分析材料或者在材料容器中分析(3b 级激光器),还有一个小管支架套筒用于分析玻璃小管中的样本(1 级激光器)。

CONFIGURATION



i-Raman Prime 785H

该 i-Raman® Prime 785H 是一种高物料通过量、低噪声且完整集成的拉曼系统,内置平板电脑和一个光纤采样探头。该便携式拉曼光谱仪带有高量子效率、TE 深度冷却功能 (-25 ° C)、高动态范围的 CCD 阵列检测器,可实现研究级别的拉曼分析,包括实时定量和鉴定。由于具有较高的物料通过量,拉曼光谱提供了极佳的信噪比,并借此可以测量更快速的过程,并且即使是最弱的拉曼信号也可以检测到细微的样品差异。

除了其移动式结构形式外,该 i-Raman Prime 785H 具有宽光谱范围和高分辨率的独特组合,并进而可以进行 150 cm^{-1} 至 2800 cm^{-1} 的测量。该 i-Raman Prime 可使用蓄电池运行,并进而方便运输。因此,无论什么地方都可以进行研究级别的高精度以及高质量和高定量的高质量拉曼分析。该系统经过优化,可与我们的 STRaman® 技术搭配使用,可用于通过非透明包装进行分析。