Copolymers have become increasingly commercially relevant due to the development of polymers with engineered properties. For example, acrylonitrile butadiene (ABS) for thermoplastics or styrene-butadiene (PS-PB) for car tires.

NMR Spectroscopy is a proven analytical technique for the characterization of fundamental polymer parameters because, in a single experiment you can:

1) Observe reaction completion & uniformity. Unreacted monomers are easily observable due to well-defined and resolved lines among the broad polymeric resonances.

2) Quantify the relative composition through pre-defined integral regions.

3) Quantify the relative percentages of structural isomers (e.g., branched vs. linear).

4) Observe tacticity and stereoisomers

5) Determine molecular weight, molecular number and polydispersity index (PDI)

Polymer characterization has been performed on traditional NMR systems for years, but now this technique is also available directly on the benchtop. The affordable, lightweight and intuitive NMReady-60 is perfectly suited to improve analytical workflow. This high-resolution 60 MHz spectrometer generates results that are comparable and statistically equivalent to a high field super-conducting spectrometer. Unlike traditional spectrometers, however, the NMReady-60 is low maintenance, robust and easy-to-use.

**Specifications:**
- Frequency: $^1$H 60 MHz, $^{31}$P 24 MHz
- Magnet: permanent, cryogen-free
- Stray field: confined within enclosure
- Uses Stanard 5 mm NMR Tubes
- Spectral resolution:
  - LW at 50%: 1.5 Hz
  - LW at 1%: <25 Hz
- Power: 100-240 VAC, 50-60 Hz
- Weight: 50lbs
- Dimensions: 9.5 x 11 x 17"
- User Interface: Built-in Touchscreen
- Connectivity: USB, Ethernet

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Around the world millions of tonnes of copolymers are produced annually. By varying the polymerization process (e.g., the order and/or quantity of monomers added, the monomer ratios etc.), the polymer's properties are fine-tuned. On the NMReady, reaction completeness, relative composition, and the ratio of structural isomers can be characterized within minutes. These capabilities are illustrated here for PS-PB and polystyrene-polyisoprene (PS-PI).

At a glance, it is clear that the reaction is complete and that there is no monomeric material remaining. The relative composition of the copolymer can then be reliably determined by: (i) normalizing; and (ii) correlating the integrals of the aromatic region (i.e., the styrene component) and the olefin region (i.e., the butadiene or isoprene component).

Similarly, the internal/terminal isomerism of the olefin component can be quantified by looking at the relative ratios in the 5-6 ppm range for all three polymeric samples shown here.

Through numerous trials, the results acquired on the 60 MHz NMReady are consistent with those obtained on a 400 MHz spectrometer. See the adjacent table for sample results obtained for one PS-PB, and two different PS-PI samples.

The characterization of polymers is only one potential application for the NMReady-60. For more information on this, or for other ideas of how to include a benchtop NMR spectrometer into your daily workflow, please visit or contact us directly.

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