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Data Article

# Background data for modulus mapping high-performance polyethylene fiber morphologies

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ABSTRACT

The data included here provides a basis for understanding "Interior morphology of high-performance polyethylene fibers revealed by modulus mapping" (K.E. Strawhecker, E.J. Sandoz-Rosado, T.A. Stockdale, E.D. Laird, 2016) [1], in specific: the multi-frequency (AMFM) atomic force microscopy technique and its application to ultra-high-molecular-weight Polyethylene (UHMWPE) fibers. Furthermore, the data suggests why the Hertzian contact mechanics model can be used within the framework of AMFM theory, simple harmonic oscillator theory, and contact mechanics. The framework is first laid out followed by data showing cantilever dynamics, force-distance spectra in AC mode, and force-distance in contact mode using Polystyrene reference and UHMWPE. Finally topography and frequency shift (stiffness) maps are presented to show the cases where elastic versus plastic deformation may have occurred.

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**Specifications Table**

| | |
|---|---|
| Subject area | *Physics & Physical Chemistry* |
| More specific subject area | *Atomic Force Microscopy (AFM) & Ultra-high-molecular-weight Polyethylene (UHMWPE)* |
| Type of data | *Figure* |
| How data was acquired | *Data collected using the Cypher AFM* |
| Data format | *Raw* |
| Experimental factors | *Spin-cast Polystyrene reference, interior-exposed UHMWPE fiber* |
| Experimental features | *Data elucidates the AMFM multi-frequency technique and its application to UHMWPE fiber samples* |
| Data source location | *Aberdeen Proving Ground, MD, USA* |
| Data accessibility | *Data is with this article* |

**Value of the data**

- This data shows the applicability of the multi-frequency (AMFM) modulus mapping AFM technique to UHMWPE fiber samples.
- The data provides a basis for understanding the interaction of an AFM tip with the material to recover tip-sample stiffness.
- The data helps to provide an estimate of the peak force experienced through the tip-sample interaction as well as provides a reason for applying a Hertzian analysis to the AFM data.

## 1. Data

In order to establish the utility of the multi-frequency technique for the purpose of this study [1], details are provided here to include resonant frequency and thermal tune spectra, AC and contact mode force curves. Additionally, Hertzian contact mechanics model fits are applied to curves performed on both PS and UHMWPE. Finally, topography and frequency (i.e. stiffness) maps are shown from before and after the force curve experiments.

## 2. Experimental design, materials and methods

### 2.1. Atomic force microscopy, AMFM theory

AMFM is a multi-frequency technique where the cantilever is excited at its mode 1 and mode 2 bending frequencies simultaneously. Background as to how the mode works as is appied using a contact mechanics model are found in the literature [2]. While this AFM technique has similarities to other AFM modulus mapping techniques such as fast force curves, although these other techniques include different cantilever and contact dynamics as well as typically a different contact mechanics model. The first bending mode is used in the feedback loop for standard AFM tapping imaging. The mode 2 bending frequency is used to evaluate the tip-sample stiffness and solve for the contact modulus through the following calculation. These resonant frequency spectra are shown in Fig. 1. The spring constant is measured by the thermal tune method [3]. Data illustrating this is seen in Fig. 2.

To illustrate the cantilever dynamics, Figs. 3 and 4 show the amplitude versus distance and the phase versus distance spectra, respectively. These are shown for both the spin-cast PS (Bruker) and

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