Calculation of Scattering from Polyethylene Particles Compared with Terahertz Measurements

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The Terahertz (THz) portion of the electromagnetic (EM) spectrum that lies between the microwave and infra-red spectrums ($1\,\mathrm{THz} = 10^{12}\,\mathrm{Hz}$) and has remained almost entirely unexplored due to difficulties in the generation and detection of energy at these frequencies. With the advent of ultrafast optical laser technologies, the ability to generate and detect energy is enabling the exploration within this so-called THz-gap. One potentially promising application of THz spectroscopy is the detection of explosive materials, and initial measurements indicate that explosives may have unique spectral characteristics in this region. However, the scattering physics that gives rise to these signatures is only beginning to be explored, and may be critically effected by the granular composition of most explosive materials.

In this paper, formulations for the EM scattering from collections of spherical scatterers are developed and applied to granular materials representative of explosive materials. Calculations are presented for pellets comprised of polyethylene (PE) powder. This spectrophotometric grade powder is manufactured by Sigma-Aldrich and has been used as a pellet binder in experiments focused on the detection of RDX explosive. In this paper, the transmission characteristics of PE itself are computed using a random media model consisting of uniformly distributed Mie spheres with a log-normal size distribution. The result of the Monte Carlo computation is compared with FTIR spectroscopy acquired from PE samples obtained from two different manufactured bins, and the two bins were observed to have markedly different grain size distributions. As expected, the observed scattering is strongly grain-size dependent. Implications and future research on this topic are discussed in the context of evaluating the ability to use THz spectroscopy for explosives detection.