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THz Spectroscopy of Artists' Pigments, Binders and Canvas

Recent developments in Terahertz (THz) radiation open up applications in non-destructive and non-invasive analysis of artworks of cultural significance. This spearheads large interest in areas such as conservation science [1]. This arises due to favorable THz characteristics, which show large transmission for materials such as paints and plastics, as well as biological materials such as wood [2].

We present data using THz radiation to analyse a series of canvas substrates, binders and paint pigments used in artistic paintings with cultural significance. These were acquired using z-omega Z2 and Advantest TAS7500 Spectrometers utilising Time Domain Spectroscopy (TDS). Our studies cover a 0.1-7THz range. We investigate canvas including polyester, cotton and linen with raw material and preparation mediums such as priming agents present in the canvas weave. The binders cover multiple constituents including oils (linseed, poppy, walnut and safflower), varnishes, fat, acrylics and waxes. We explore 47 pigment samples consisting of organic and metallic based grounds including iron, carbon, cadmium and zinc.

Canvas samples exhibit a large number of features, most likely of phonon origin, in the 0.1-7THz range. Polyester canvas shows an absorption at 3.4THz. Coarse Linen exhibits a sharp absorption at 2.4THz in conjunction with a broad absorption at 1.6THz. Cotton Duct canvas displays two broad absorptions at 1.2 and 2THz. Belgian Linen primed with oil was featureless, however, when primed with clear glue two broad absorptions develop at 1.6 and 2.8THz. Thus different canvas and preparation processes are distinguishable by THz radiation.

Binders were likewise found to show unique spectra. The natural oil binders presented broad features in one of (or both) a 2-2.3THz region and 3.1-3.3THz region. Despite this, relative shifts between the features and the absence of some features conserve distinctiveness to individual spectra. Two wax binders measured were indistinguishable with no appreciable features. Acrylics, fats and varnishes showed combinations of sharp features at 2THz and near 3THz with various broad absorptions across the range, all of which are unique.

Pigment samples investigated in the 0.1-1THz region illustrate identification capabilities between optically identical pigment colour obtained from different suppliers, for example, the Blauw extra, Blauw Donker and Hollands Blauw pigments. Pigments of different raw constituents, such as zinc, cadmium, carbon and iron are also identifiable.

Our results show unique and distinguishable spectra, especially for canvas materials and binding agents. This 'finger print' for each spectrum is desirable as it validates applications of THz radiation in identifying constituent materials used in paintings. This is especially relevant to older pieces where information about the painting materials and process have been lost over time.

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