Characterization of Organic Dyes that Show Enhancement when Tested with Surface Enhanced Infrared Techniques

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Introduction

The field of Surface-Enhanced Infrared Absorbance (SEIRA) has been slowly emerging over the past two decades. In this area of study a thin metal layer is introduced to enhance Fourier Transfer Infrared (FTIR) spectroscopy signals. The enhancement phenomena was first observed on coinage metal films like platinum, tin, and lead, and recently, it has been discovered that polar dielectric nanoparticles cause enhancement.[1] This occurs because there is a change in the electrical field around where the nanoparticles and organic molecules are in close contact.[2] The most efficient way of putting these particles in a position to be enhanced is to use an Attenuated Total Reflectance (ATR) stage, an insert for an FTIR instrument that focuses the infrared (IR) light directly on the substance being examined. This stage is used in the FTIR spectroscopy process as a convenient way to scan both liquids and solids without involving complicated chemical preparation.

The goal of this research was to identify a specific structure in organic dyes that will consistently show enhancement. In this way we will be able to more accurately understand and study the enhancement process and what causes the enhancement.

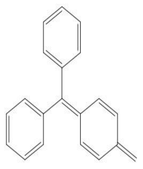
Methods

Alumina Suspension Preparation

•Scrape alumina particles off a TLC plate and place in acetone

Alumina Suspension on the Infrared Spectrometer

•Place 4.31×10^{-7} mmol alumina on ATR crystal and let dry
•Place 2.00×10^{-5} mmol of desired dye on ATR crystal and let dry
•Take 100 scans of the sample at resolution of 2.0 cm^{-1}



Basic enhancement group

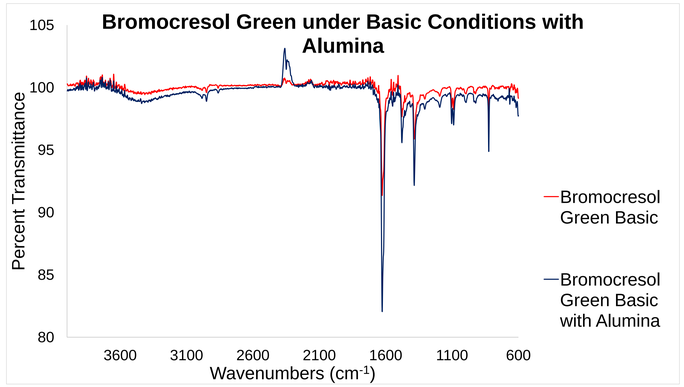
ATR stage with diamond crystal

Diamond Crystal on ATR Stage

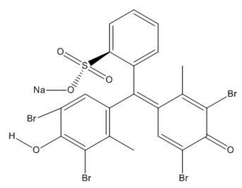
Dyes that Show Enhancement

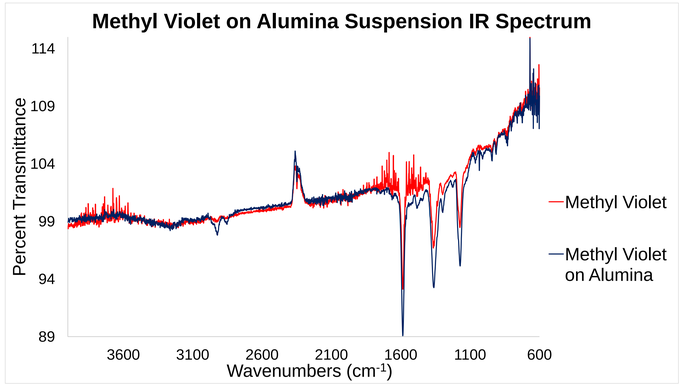
- Methyl violet
- Crystal violet
- Phenol red (pH > 8.2)
- Malachite green
- Fuchsine
- Bromocresol green (pH > 5.4)
- Phenolphthalein (pH 8.2-12.0)
- Bromocresol purple (pH >6.8)
- Bromophenol blue (pH>4.6)

Results

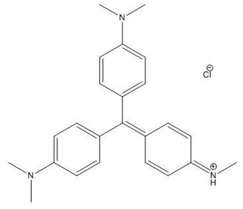


Bromocresol Green (pH >5.4)			
Wavenumbers (cm^{-1})	Without Alumina	With alumina	Peak Ratios
1625	9.32	18.10	1.94
1477	3.28	4.51	1.37
1384	3.48	6.49	1.86
1306	0.31	0.42	1.37
1192	0.41	0.64	1.56
1088	1.74	2.48	1.43
993	0.38	0.59	1.53
922	0.49	0.70	1.42
824	3.10	4.45	1.44

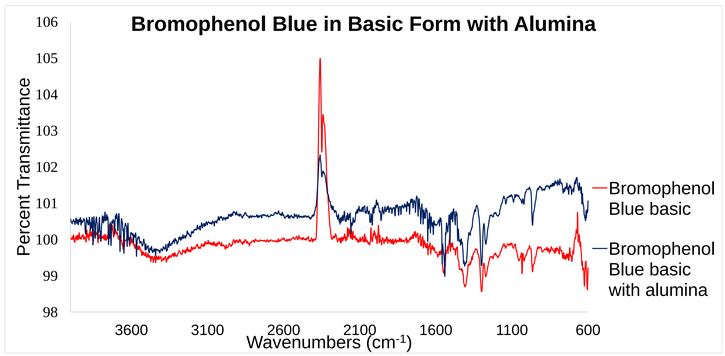




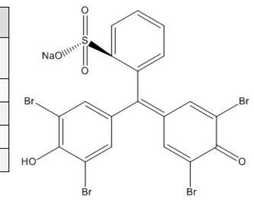
Methyl Violet			
Wavenumbers (cm^{-1})	Without Alumina	With alumina	Peak Ratios
1586	7.82	11.11	1.42
1361	4.72	7.62	1.61
1172	4.14	6.69	1.62



Results



Bromophenol Blue (pH>4.6)			
Wavenumbers (cm^{-1})	Without Alumina	With alumina	Peak Ratios
1541	0.61	1.55	2.56
1410	1.03	1.46	1.41
1298	1.05	1.59	1.51
964	0.64	0.95	1.47



Conclusion and Future Directions

- Triphenylmethyl dyes with conjugation show enhancement
- Triphenylmethyl dyes in basic conditions enhance
- Triphenylmethyl dyes with central planar structure enhance
- Investigate what molecular shapes show the best enhancement
- Test dyes with other structures for enhancement
- Find other dielectric nanoparticles that will cause enhancement

Literature Cited

1. Aroca, R.; Ross, D. Surface-Enhanced Infrared Spectroscopy. *Materials & Surface Science Group* **2004**, *58*, 324A-338A.
2. Anderson, M. Enhanced Infrared Absorption with Dielectric Nanoparticles. *Appl. Phys. Letter* **2003**, *83*, 2964-2966.

Acknowledgments

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