Volume 3, Number 2 March 2016

Interdisciplinary collaboration between engineering, mathematics and science

SEMS Research Highlights

Lanthanide Luminescence for Medical Applications

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This newsletter presents the research conducted within the School of Engineering, Mathematics and Science (SEMS) at Robert Morris University (RMU). It covers various relevant topics including: interdisciplinary efforts, successful research grants, student research, posters and papers, journal publications, presentations at national and international conferences, contribution to professional societies, STEM educational research, industrial consulting collaborations and applied research.

The research presented here focuses on light emission or luminescence from metallic atoms such as those from rare earth elements. Some natural materials also emit light of specific wavelengths (i.e. color), a phenomenon called fluorescence, which however is a short-lived phenomenon and has shortcomings when used for medical diagnosis. Figure 1 shows the comparison of the rapid decay of fluorescence of organic materials as compared to the longer lifetimes of inorganic luminescence.

Metallic emissions, specifically those from the lanthanide series such as Nd^{3+}, Yb^{3+}, Eu^{3+}, Tb^{3+}, Gd^{3+}, and Er^{3+} have long-lived luminescence due to the nature of the *f* electrons involved. However, it is difficult to get these metals to fluoresce. So, a technique is used here where some organic ligand is bonded to the metal atoms so that the organic material can act as an antenna to absorb the incident light and transmit the energy to the metal atoms. This energy causes the electrons in the *4f* shell of the metal atoms to be promoted to an excited state and then subsequently emit light as they return to the ground state. In some cases, radiation emitted by these electrons is in the Near Infra-Red (NIR) range where wavelength is 700 — 850 nm as compared to the visible light in the range 450 —700 nm.

This luminescence is important as shown in Figure 2, due to the minimal absorbance of this light in various biological mediums. It can be seen from Figure 2 that wavelengths in the region 700—900 nm are absorbed the least in the biological media tested. This means that if biological markers are made using Nd^{3+}, then their emission can penetrate deep into skin, blood and tissue thus making human body transparent to this radiation. In this way, it is possible to use these materials in the analysis and diagnosis of medical conditions.

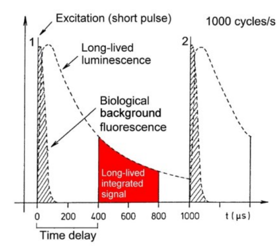

Figure 1. Luminescence lifetimes of organic and lanthanide metallic materials.

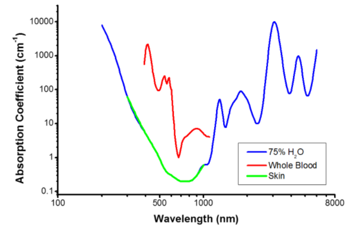

Figure 2. Absorption coefficient as a function of wavelength (nm) for 75% water (blue), whole blood (red) and skin (green).

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