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Novel Flourescent Sensors for the Detection of Organic Molecules in Extraterrestrial Samples

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Organic compounds in extraterrestrial samples have mostly been elucidated by destructive analytical techniques therefore information regarding spatial relationships between minerals and organic species is lost. Minerals form under specific chemical and physical conditions so organic compounds associated with these minerals are likely to have formed under the same conditions. It is therefore possible to infer in which cosmological provinces their chemical evolution took place. We will describe progress towards developing fluorescent sensors that may resolve spatial discrimination.

Lanthanide elements such as europium and terbium produce well defined line-like, high intensity and long lived fluorescent emissions. Interactions with organic molecules may alter the luminescent emission characteristics. The lanthanide atom needs to be rendered chemically inert but must remain susceptible to these organic molecule interactions. An organic ligand must be employed to attain this. DOTA (1,4,7,10-tetraazacyclododecanetetracetic acid) was chosen as a plausible organic ligand because its structure, a tetra-substituted cyclen ring, and ability to chelate are well characterized. It is also commercially available. Fluorescent lanthanide-DOTA complexes are used in many biological and analytical imaging applications so it is logical to investigate their applicability to fluorimetric analysis of extraterrestrial organics. Lanthanide-DOTA complexes are very stable because the lanthanide metal atom is enveloped within the DOTA structure. Experimental procedures were designed to investigate lanthanide/analyte interactions and their effect upon fluorescent emissions.

A range of compounds were chosen giving a good representation of the organics identified in extraterrestrial samples and whether they may to interact with the lanthanide metal ion. An Europium-DOTA baseline fluorescent spectrum was obtained and compared against Europium-DOTA/analyte mixtures of a range of concentrations resembling those present in extraterrestrial samples. Upon collation and analysis of results a much reduced set of analytes were chosen for experimentation with Terbium-DOTA.

Results showed no change in fluorescent intensity or emission spectrum for any of the analytes at the concentrations found in extraterrestrial samples (μM to nM). This could be due to no interaction at any concentration of analyte or there is an intrinsic limit of detection. Experiments were carried out at equimolar concentration with fewer analytes. It was found that here was an increase in fluorescent intensity for some analytes and decrease for others (e.g. adenine and ornithine, respectively). There was no discernible trend in behaviour according to analyte structure or how they might interact as a result. Attention has now turned to the tris-substituted cyclen ring, DO_3A, which could afford improved scope for interaction.

DOTA is an unsuitable ligand to use for the sensor. Experimentation has shown that neither lanthanide-DOTA complexes exhibited a change in fluorescent spectrum; the ligand requires modification not the choice of lanthanide. We will present results from the development and preliminary testing of the DO_3A sensor.