Scientists to create galactic building blocks to study the space between stars

April 10 2017, by Colin Smith

Researchers are planning to synthesise a class of chemical compounds to determine whether they are an important building block for making galaxies.

The team from Imperial College London has received seed funding from the Institute of Molecular Science and Engineering (IMSE) to forge ahead with a new project. The aim is to use synthetic chemistry to prepare several aza-polycyclic aromatic hydrocarbons (aza-PAHs) that are proposed to be part of the interstellar medium. The target compounds are very rare on Earth and could hold the key to understanding more about the birth of stars, and the formation of solar systems and galaxies.

Professor Mark Sephton, Head of the Department of Earth Science and Engineering, along with Dr Wren Montgomery, also from the department, are teaming up with Dr Matthew Fuchter, from Imperial's Department of Chemistry. This group is one of the first, along with six other new research projects to receive funding from IMSE's proof-of-concept seed funding initiative.

Colin Smith caught up with Drs Montgomery and Fuchter to learn more about aza-PAHs and what synthesising them in the lab could mean for our understanding of the universe.

Dr Wren Montgomery, Department of Earth Science and Engineering

What are aza-PAHs?

These consist of rings of carbon atoms together with a few nitrogen atoms. Scientists classify them as either "smaller" or "larger" depending on the number of carbon rings they contain.

Where are they found?

On Earth, smaller aza-PAHs (two to three rings) are pollutants associated with asphalt and tar.

Out in the wider universe, larger aza-PAHs (seven rings or more) are thought to be a key part of the interstellar medium (ISM). This is the matter that exists in the space between star systems in galaxies. This matter includes gas in ionic, atomic, and molecular forms, as well as dust and cosmic rays. It fills interstellar space and blends smoothly into the surrounding intergalactic space.

Scientists believe that larger aza-PAHs are important ingredients in the ISM, but it has not been previously possible to get enough pure samples of these on Earth to take measurements in a laboratory to determine if this hypothesis is correct.

How will this seed funding help us to learn more about them?

We are planning to create synthetic aza-PAHs in the laboratory and study them using a device called Fourier Transform Infrared Spectroscopy (FTIR), which uses light in the infrared spectrum to study molecules in detail.

Currently, astronomers use infrared instruments to study the ISM. We plan to make a direct comparison between our synthesised samples and the actual ISM. This will help us to reveal the nature and distribution of the organic building blocks of the cosmos and its planetary systems.

We also plan to study aza-PAHs in high-pressure environments. This will help us to understand how they are altered or possibly destroyed by the processes of stars and planets forming.

If you successfully create aza-PAHs in the lab what

could it tell us about the universe?

Firstly, having a sample can verify the existing models developed by scientists and tell us whether or not aza-PAHs are present in the ISM.

If they are present, then their behaviour under high pressure will tell us something about what happens to them when the molecular cloud condenses and forms planets. They're very scarce on Earth today, so perhaps our work can shed some light on where have they gone.

What are some of the challenges of this project?

This class of chemical compound will be very difficult to "manufacture" in the lab. We will be covering new ground in terms of how we work with Mark Fuchter in Imperial's Department of Chemistry. One of the big challenges for us will be to find a way for our two different sciences to "talk" to one another so that we can achieve our goals. It will be a very exciting and creative process.

Dr Matthew Fuchter, Department Of Chemistry

What unique qualities will you bring to this project?

My group has expertise in synthetic chemistry: the ability to build more complex molecules from simple precursors.

In particular, we have developed methods to construct polycyclic aromatic compounds – a key target molecular class for our research - and so have the correct background to try and construct the the target molecules needed for this project.

Why is this seeding funding important?

These target molecules have never been made in sufficient quantities to be fully characterised by scientists, so their synthesis and study would be a world first.

Are there other applications for this research?

Outside of the specific aims of this project, the chemical compounds should have other interesting applications. For example, they could be used in the construction of organic electronic devices. A key example of current organic electronic technology is the light emitting diodes, which are currently used in smartphone displays.

My group, together with collaborators in Imperial's Department of Physics, has an ongoing research programme, which concerns the use of new condensed aromatic molecules in novel devices and materials. Therefore, this project could additionally seed other new directions of research for my collaborators and me.

What are the benefits of being aligned with IMSE?

One of IMSE's key aims is to foster new collaborations across all four faculties at Imperial around ambitious grand challenge projects. Through their seed funding scheme, Mark, Wren and I have established a new collaboration between departments with complementary strengths to work on an exciting, integrated new project area.

Provided by Imperial College London