Engineering and Innovation Research Studentship October 2020

Project title:	Low cost coating of 2D functional nanomaterials for steel
Discipline	**Engineering and Physics**
Key words:	Barrier coatings; nanomaterials; Graphene; MXENE; plasma technology; Raman and contact angle measurements, XPS, Atmospheric plasma functionalisation
Supervisory team:	**Satheesh Krishnamurthy, Nicolas Braithwaite, Samson Patole**
URL for lead supervisor's OU profile	**http://stem.open.ac.uk/people/sk9268**

Project Highlights:

- Develop and demonstrate solutions based on 2D materials that can deliver robust, viable coatings.
- Selection and testing of materials for adhesion, chemical stability, acidic and alkaline conditions tests.
- fundamental understanding of corrosion protection will be carried out using electrochemical techniques.
- Opportunity to work with industrial partner TATA Steel.

Project Description:

In a world with limited supply of resources, and where corrosion and its mitigation account for 3-4% of GDP of the industrialised countries and 4.2% or 180 billion dollars in the USA alone, any technology that helps to reduce the corrosion lone will have significant impact on economy, environment and hence climate change.

Barrier coating is one of the widely applied strategies to reduce degradation of materials, however, every coating technology has its drawbacks. 2D materials such as Graphene and its different forms, Molybdenum sulphide, HBN, newly found MXENE, has promising properties such as atomically thin, impermeable to molecules and hence will arrest corrosion. Earth abundant 2D materials are promising candidates for effective, robust, and economical corrosion passivation coatings due to their ultimate thinness and excellent mechanical and electrical properties

The aim of this project is to develop and demonstrate solution based on 2D materials that can deliver robust, viable coatings. The project is two-fold (A) is the selection of 2D materials and functionalisation with desired properties and (B) make inks /coatings generated by (A) for inhouse plasma functionalization on to steel (supplied by TATA Steel). By using the method (B) we will perform multilayer functionalisation of materials using our roll to roll deposition techniques such as atmospheric pressure plasma, traditional coil coatings, slot die coatings etc to circumvent the drawback of traditional corrosion resistant materials.

Research Methods:

Selection of materials and after functionalization and deposition the following properties will be tested in OU and also in TATA Steel Coventry; adhesion of the materials by doing scratch test, pull off , deformation, soil test and others (TATA Steel), chemical stability, acidic and alkaline conditions tests (OU). Basic electronic and morphological studies will be performed and optimised (OU) will give necessary information on the mechanical properties of the material. High temperature studies along with oxygen uptake/evolution will be carried out using electrochemical set up at (OU). These electrochemical tests are necessary, as they highlight the influence of barrier layer the life cycle analysis of how these coatings will address the fundamental problem undergone by traditional methods.

The final prototype coating will be field tested at TATA steel site.

Indication of project timeline:

Year 1: Literature survey and selection of new materials and functionalisation
Year 2: Coatings and optimisation of selected material and its understanding of deeper mechanism by various surface analytical techniqiues. Conference presentation and field trials.
Year 3: Prototype development and testing at site, Complete thesis write-up.

Background reading:

1. Engineering work function of graphene oxide from p to n type using a low power atmospheric pressure plasma jet, A. Dey, P. Ghosh, J. Bowen, N.St.J. Braithwaite and S. Krishnamurthy, 2020, Physical Chemistry Chemical Physics, in press, https://doi.org/10.1039/C9CP06174F
2. Synthesis of MoS 2-TiO 2 nanocomposite for enhanced photocatalytic and photoelectrochemical performance under visible light irradiation, M. Mehta, A. P Singh, S. Kumar, S. Krishnamurthy, B. Wickman, S. Basu, 2018, Vacuum, 6,6
3. Plasma Jet Printing and in situ Reduction of Highly Acidic Graphene Oxide, Avishek Dey, Satheesh Krishnamurthy, James Bowen, Dennis Nordlund, M Meyyappan and Ram P Gandhiraman, 2018, ACS Nano, 5,23
4. Tuning the properties of a black TiO 2-Ag visible light photocatalyst produced by rapid one-pot chemical reduction, Michael Coto, Giorgio Divitini, Avishek Dey, Satheesh Krishnamurthy, Najeeb Ullah, Cate Ducati and R Vasant Kumar, Materials Today Chemistry, 2018 142-149
5. Synthesis of MoS2-TiO2 nanocomposite for enhanced photocatalytic and photoelectrochemical performance under visible light irradiation, Manan Mehta, Aadesh P Singh, Sandeeep Kumar, Satheesh Krishnamurthy, Björn Wickman, Suddhasatwa Basu, Vacuum, 2018, 675

Candidate Applications:

Students should have (or expect to obtain) at least the equivalent of a UK upper second class honours degree (and preferably a Masters degree) in chemistry, materials science, soild state physics or other relevant scientific discipline. Knowledge of synthetic and characterisation techniques for materials, and a broad interest in sustainable chemistry or chemical or materials engineering would be an advantage.The student will join a well-established team researching on materials functionalisation for solar energy, solar fuels and battery group.

Please contact **Satheesh Krishnamurthy** **Satheesh.krishnamurthy@open.ac.uk** for further information.

Applications should include:

- A 1000 word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- Open University application form
- Applicants will need to demonstrate good competence in the English language. To be eligible for a full award, a student must have no restrictions on how long they can stay in the UK and have been ordinarily resident in the UK for at least 3 years prior to the start of the studentship.

Applications should be sent to **STEM-EI-PhD@open.ac.uk by 24.04.20**