A study on graphene-based marine coatings
Bachelor thesis project

Background:
Surfaces of ships and offshore structures are without exception painted with marine coatings. The paints not only give the ships and platforms a better appearance, but also protect the surfaces from corrosion. Corrosion, as illustrated in Figure 1(a), is a persisting problem for marine structures that are constantly in contact with sea water. Every year, corrosion related economic losses in the U.S shipping industry is at $2.7 billion. Corrosion also results in loss of structural integrity. Statistics shows that 90% of ship failures are attributed to corrosion. Another protective effects of marine coatings are anti-biofouling. Surfaces that are submerged in the sea water become rapidly covered by a biofilm of aquatic organisms. This process is called biofouling. Figure 1(b) shows a biofouling of green seaweed on a ship hull. Biofouling results in increased hydrodynamic drag, lower the maneuverability of the vessel and increase the fuel consumption. A ship hull with biofouling requires 15-20% more power for propulsion than a newly painted or maintained hull.

![Figure 1: Images show (a) a premature failure of protective coating in a ship ballast tank; (b) a biofouling of green seaweed on a ship hull.](image)

Despite of many years’ experience and even utilization of modern technologies, the performance of conventional marine coatings remain far from satisfying. This is particularly true when it comes to long-term protection of metal from aggressive environment, for which coating failure occurs most often. For the purpose of anti-biofouling, the dominating copper-based paints, in addition to their negative impact on marine environment, are only partly effective as they reduce the hard fouling organisms but do not protect against soft fouling like sea weed. It is therefore essential to develop antifouling marine coatings based on alternative materials.

Graphene is a “new” material discovered in 2004. This “miracle material” is believed to potentially revolutionize the world. Graphene is about 100 times stronger than steel and has many other extraordinary properties, which is a result of its unique molecule structure (illustrated in Figure 2). With the breakthrough of graphene, we are now enthusiastic to proceed to develop next generation marine coatings. Graphene is considered as a very promising material to be used for marine coatings due to its extraordinary properties arisen from its unique structure. Graphene has been proved to be an effective corrosion barrier material because it is inert under the conditions where chemical reactions of other substrates will take place. Literature study suggests a bright future for the use of graphene as an anti-corrosion coating material.
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Objective:
The objective of this interdisciplinary project is to examine the feasibility of development of environmentally friendly marine coatings making use of graphene-based materials to achieve a combined protection against corrosion and biofouling in marine environments.

Tasks:
The proposed project is characterized by the interdisciplinary topics: the study ought to be carried out from both the structural integrity and the marine environment perspectives. Knowledges from marine technology, marine biology, chemistry and environmental science will be involved. This project is also a collaboration between academia and industry. We will collaborate in particular with the graphene manufacturer, Smart High Tech AB and the coating manufacturer, Unica Coatings AB. The specific tasks are:
- A thorough literature study on the topic (metal corrosion, marine biofouling, coating materials, graphene and graphene composites)
- A benchmark study of marine coatings in the market
- Modelling and calculation of the corrosive degradation of graphene-based marine coating systems
- Promote the component of the novel graphene-based coating material
- Discuss the influence from uncertainty in modelling and material characteristics.

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