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Abstract

Predicting Environmental Ageing of Composites: Modular Approach and Multiscale Modelling †

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Abstract: Fibre-reinforced composite materials are used in structural applications in marine, offshore, and oil and gas industries due to their light weight and excellent mechanical properties. However, the exposure of such materials to water leads to environmental ageing, weakening the composite over time. A typical design lifetime of offshore composite structures, being in direct contact with water and humid air, spans 25 years or more. Thus, the prediction and modelling of environmental ageing phenomena has become highly important, especially for predicting long-term environmental durability. In this study, a systematic and modular approach for quantitatively modelling such phenomena is provided. The modular methodology presented in this work can, and should, be further expanded—it is multiscale and scalable. A state-of-the-art degradation framework is not yet complete; however, it is a systematic step towards the multiscale modelling paradigm for composite materials. The topic of the environmental durability of composite materials is being actively developed and is expected to continue growing in the future. There are three constituents in a composite: matrix, fibres, and an interphase. Each constituent degrades differently and may also affect the degradation behaviour of each other. Therefore, a modular multiscale approach is preferred. The modules are based on the physics and chemistry of individual constituents' interaction with the environment, including the diffusion, molecular mechanisms, and kinetics of environmental ageing [1–26]. The methodology is seen as a useful approach for both industry and academia, including such use cases as accelerated testing, prediction of the lifetime of composite materials and structures, as well as improving the understanding of environmental ageing effects and the time-dependent properties of composites due to environmental ageing.

Keywords: composite materials; environmental ageing; multiscale modelling; accelerated ageing; lifetime prediction

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