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Investigate the effects of hydrogen-rich environment on the tensile properties of thermoplastic polymers for liquid hydrogen service

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Adopting hydrogen fuel has been recognised as a promising route to realise net-zero emission by academia, industry and government. It is challenging to most materials for storing and distributing liquid hydrogen at 20 Kelvin (K). While metallic materials have traditionally been considered for liquid hydrogen storage and distribution, recent discourse in both academia and industry, particularly within the aviation sector, has increasingly explored the use of light-weight materials for constructing liquid hydrogen tank structures, such as fibre-reinforced composite materials. However, the substantial weight of metallic materials and the occurrence of microcracks due to mismatches in coefficients of thermal expansion between fibres and resin have constrained their utility for liquid hydrogen storage and distribution. Thermoplastic polymers have emerged with potential solution for liquid hydrogen storage and distribution components. High density thermoplastic polymers have already been explored when acting as the liner material on Type IV tanks holding compressed hydrogen gas at room temperature and 350 bar pressure [1]. Thermoplastic polymers might provide solutions for seals in components like pipeline joints, valves, pumps and flexible hoses [2,3] for transferring cryogenic hydrogen. However, there is limited study about the behaviours of these polymers at 20 K. The authors have conducted the first study of the strain rate effects on the mechanical behaviours and failure mechanisms of three candidate thermoplastics with promising performance at 20 K. The coefficients of thermal expansion between 300 - 4 K were also measured to guide the design of potential sealing configurations for hydrogen service down to 20 K. More fundamental is the current knowledge gap surrounding the performance of thermoplastics operating consistently at cryogenic temperatures and possible deterioration in mechanical properties after exposing to hydrogen-rich environment for long-periods. This new study will aim to characterise the long-term effects of hydrogen aggression on the tensile properties of thermoplastic polymers at 20 K. Three types of thermoplastic polymers Polypropylene (low molecular weight), FEP (medium molecular weight) and PEEK (high molecular weight) are deliberately selected to inspect possible variations with molecular weight. All materials will be tested as thin films to encourage more rapid hydrogen diffusion and absorption into the material, with the aim to amplify any effects. The hydrogen gas charging technique will be deployed to soak samples inside a pressure vessel rated for 200 bar and up to 373 K. The achievement of hydrogen saturation is traced using a Hy-Energy gas absorption analysis system. Finally, the hydrogen absorption rate of the three polymers, the duration required to obtain "full charged/saturated"samples given the current state-of-art, and the effects of hydrogen-enrichment upon the tensile properties of thermoplastic films at 20 K will be summarised and discussed.

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References

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