Experimental study of flame spread over flame retardant glass fiber-reinforced epoxy resin in opposed oxidizer flow

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The high flammability of glass fiber-reinforced epoxy resin (GFRER) is a factor, that limits its propagation in industry. Traditional flammability and thermal stability tests can provide assessment of materials flammability in the most cases. The flame spread experiments under different ambient conditions are necessary to understand the mechanism of flammability reduction in details to develop new more effective materials and flame retardants.

This work is focused on flame spread over GFRER in opposed oxidizer flow. GFRERs with 35% and 50% binder content (BC) and addition of DDM-DOPO and graphene were prepared. It was noticed that the samples with lower limiting oxygen index (LOI) had higher downward flame spread rate (ROS) in opposed O_2/N_2 mixture flow, but that was observed only near a flammability limit of the samples (LOC). At higher oxygen concentrations, there was no strict dependence between LOI values and flame propagation rate. Approximately the same gap between LOC and LOI values for GFRER samples was observed due to difference of the flame zone in LOI test and downward flame spreading experiments. In the downward flame spread in opposed oxidizing flow, DDM-DOPO and DDM-DOPO + graphene flame retardants slightly reduced ROS for GFRER with BC~35%. Moreover, the effect of flame retardants regarding the reduction in measured ROS for GFRER1 samples (with ~ 35%BC) at O_2 concentrations greater than 47.5 vol.% practically disappeared. For the samples with BC~52%, DDM-DOPO reduced ROS on ~15% for all tested O_2 concentrations. It was concluded, that the mixture of 5 wt.% graphene + 5 wt.% DDM-DOPO was more effective additive than only 5 wt.% DDM-DOPO additive for GFRER samples with different BC. The results of numerical simulation of flame propagation over the surface of GFRER have shown that the model is able to predict ROS and temperature for samples with binder content of ~33 ± 3%, while as the amount of binder increases, the role of the thermophysical properties of volatile pyrolysis products increases, which leads to underprediction of the model.

In conclusion, dependency between ROS, LOI and UL94 results were found. The obtained data may be used for improving numerical models, for designing effective reinforced non-combustible composites applied in the aircraft industry and for justifying standard flammability tests.

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