

## ABSTRACT

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In the last few decades, shear thickening fluid (STF) impregnated fabrics have generated huge interest amongst the researchers attempting to engineer light-weighting and flexible body armour. The non-Newtonian STF undergoes unique liquid to solid transition under stressed condition, thereby augmenting the impact energy absorption of the fabric treated with it. Both the constituents of STF, i.e., dispersion medium and dispersed phase, significantly influence the nature and extent of shear thickening. Thus, this research focuses on understanding the role of chemical interactions between these constituents in determining the rheology of silica particle and polyethylene glycol (PEG) based STFs, as well as the impact resistance behaviour of high-performance fabrics treated with such STFs.

The first part of this research involved studying the effect of micro and nano fibrous additives on the rheological performance of prepared multi-phase STFs. Cellulose nanofibres (CelNF) and Kevlar microfibrils (KMF) were extracted by a novel grinding technique and subsequently added to the silica-PEG 200 STF system. A miniscule amount (0.1 to 0.3 wt. %) of CelNF significantly increased the peak viscosity and decreased the critical shear rate owing to the presence of a large number of surface -OH groups, consequently helping in better H-bond formation among STF constituents. The maximum increase of 278% in peak viscosity with respect to neat STF was observed for 0.2% CelNF based STF. It was also attempted to establish the role of surface chemistry of additives using surface modified (hydrophobic) CelNF i.e., M-CelNF reinforced STFs which showed decreased peak viscosity due to their relatively inert surface. The rheological response of both the variants of CelNF reinforced STF was translated to impact energy absorption of the fabrics treated with them. The KMF reinforced STFs showed diminishing rheological response owing to inert surface chemistry and micron size (thickness) of KMF. However, this reduction in rheological performance was not reflected in the impact resistance performance of the fabrics treated with KMF reinforced STFs.

The effect of molecular weight of carrier fluid on the rheological performance of an STF was explored in the second part of this research. Different high molecular weight PEGs (HMW-PEG: 1000, 3000 and 6000 g mol<sup>-1</sup>) were individually added to a mixture of PEG 200 and PEG 600 to prepare ternary mixtures of carrier fluids. Increase in average molecular weight

of the carrier fluid via addition of HMW-PEG 1000 and 3000 enhanced the peak viscosity values by 88% and 832%, respectively with respect to neat STF. On the other hand, addition of HMW-PEG 6000 led to a rheological response inferior to that obtained via addition of HMW-PEG 3000 owing to solidification of the former at room temperature, subsequently resulting in fusion of silica particles. However, an inverse correlation was observed between the rheological behaviour of HMW-PEG based STFs and impact resistance performance of fabrics treated with them. The possible reason is lubrication caused by long polymer chains of HMW-PEG, which was confirmed from yarn pull-out results.

An attempt was made in the third part of this research to study the effect of chemical modification of carrier fluid on the rheological performance of STFs. STF prepared using citric acid modified PEG 200, i.e., M-STF, exhibited 76 times increase in peak viscosity owing to alterations in both chemical structure (hydrophilic functional groups) and molecular chain length. Besides, the impact energy absorption by M-STF treated fabric was also 35% higher than that of fabric treated with neat STF.

In the last part of the research, an attempt was made to understand the role of particle surface chemistry in tailoring the rheological behaviour of STFs. Silica particles were functionalised by hydrophilic and hydrophobic silane coupling agents (two each) at three different concentrations (3, 6 and 9 % on the wt. of silica particles). The hydrophilic particles based STF showed better rheological properties than neat STF because of stronger inter-particle interaction forces (more H-bonds) in the former. On the contrary, STF prepared using hydrophobic particles exhibited inferior rheological properties due to weaker inter-particle interactions. Interestingly, it was found that along with rheological behaviour of STFs, the pattern of their distribution over the fabric surface (governed by STF-fabric interactions) also played an important role in determining the impact resistance performance of fabrics treated with these STFs. The deposition of STF in the inter filament or inter yarn gaps was found to favour the enhancement in impact resistance performance rather than its uniform distribution over the fabric surface.