**Abstract**

Bio based nanocomposites have become of significant interest in recent years because they might facilitate the transition from a linear economy based on the disposal of production waste to a circular economy that utilizes waste as a resource for producing new materials. They have been studied in various sectors for various reasons such as: sustainability, lightness and high mechanical resistance, improvement of barrier and thermal properties and functionalization. Among the prominent bio-based materials, nanocellulose CNF stands out for its unique properties such as non-toxicity, biodegradability, high aspect ratio, large surface area, and mechanical strength, making it highly researched for various applications. However, nanocellulose exhibits poor fire resistance, and the purpose of this thesis is to explore the use of nanocellulose in the development of flame-retardant nanocomposite.

The properties of nacre-inspired nanocomposite hybrids of TEMPO - oxidized cellulose nanofibers (TOCN) and h-BN nanoparticles are investigated in this thesis work, in order to produce a material with competitive properties compared to conventional materials and to analyze its fire retardancy behavior. TEMPO (2,2,6,6-tetramethylpiperidine-1-oxyl radical) oxidation is a process that can convert native wood cellulose into individual nanofibers, which are typically 3-4 nm wide and at least several microns long, with aspect ratios greater than 100. The TOCN was prepared by using pulp demineralization, TEMPO-mediated oxidation and finally high pressure micro-fluidification. The produced TOCN – h-BN dispersions exhibited relatively good stability with some sedimentation after a few days. h-BN/CNF bio-nanocomposites with a wide range of compositions were prepared by vacuum- assisted filtration of TOCN reinforced by exfoliated h-BN nanoparticles.

The morphological analysis was carried out using scanning electron microscopy that shows good random distribution and poorly dispersion of h-BN nanoparticles in all sample compositions. The mechanical characterization was carried out using tensile test. The samples exhibited reduced mechanical properties compared to net TOCN samples due to poor nanoparticle dispersion. The films showed a maximum fracture strength of 62 MPa for the 60% boron nitride samples and a Young's modulus of approximately 4 GPa for all compositions, significantly lower than the 14 GPa of the neat TOCN films. Spectroscopy, thermal, and fire behaviour analyses were conducted, revealing that the 60% boron nitride samples performed the best in terms of mechanical properties and fire propagation, exhibiting a self-extinguishing behaviour. Further flame penetration tests demonstrated how the poor nanoparticle dispersion negatively impacted penetration resistance.

Keywords:

Cellulose nanofibrils, boron nitride, vacuum-assisted filtration, fire behaviour, mechanical properties, morphological analysis.