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Enhancing Fire Retardancy and Mechanical Properties of *Hevea brasiliensis* Wood using Nano-Silica and Nitrogen/Phosphorus based Compounds

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INTRODUCTION & AIM

Wood is a highly advantageous material due to its low embodied energy, low carbon footprint, sustainability and overall lower greenhouse gases emissions than most alternatives. Since wood is a fire prone material, the need for protecting it against fire is very necessary.

The **nitrogen-phosphorus** (NP) based compounds have proved to be very powerful solutions as fire retardants, especially in matrices containing oxygen or nitrogen atoms in their backbone, but at the same time they bring forth some serious challenge in terms of mechanical strength loss in treated timber [1].

In the present work we intend to evaluate the effect of **ammonium polyphosphate** (APP, phase - 1), **dicyandiamide** (DCD) and **nano-SiO_2** (NS) on fire retardant and mechanical properties of ***Hevea brasiliensis*** wood.

MATERIAL & METHOD

- Clear samples of *H. brasiliensis* wood were prepared for **rate of burning test** for fire retardancy {100 mm (length) × 12.5 mm (width) × 12.5mm (thickness)}; and **flexural bending test** for mechanical properties {300 mm (length) × 20 mm (width) ×20 mm (thickness)}.
- Wood samples were treated with following compositions:
  a) Nano-SiO_2 1.5% (w/w) concentration: **$NS_{1.5}$**,
  b) NP based combination, APP (17%, w/w) and DCD (3%, w/w): **APP_{17}/DCD_3** and,
  c) Combination of $NS_{1.5}$ and APP_{17}/DCD_3: **$NS_{1.5}/APP_{17}/DCD_3$**.
- Testing of treated as well as control wood samples was conducted as per following standards:
  a) Rate of burning: As per Bureau of Indian Standards,Indian standard, **IS:1734 (Part 3)-1983**.
  b) Flexural bending: As per Bureau of Indian Standards,Indian standard**, IS: 1708 (Part 6)-1986**.

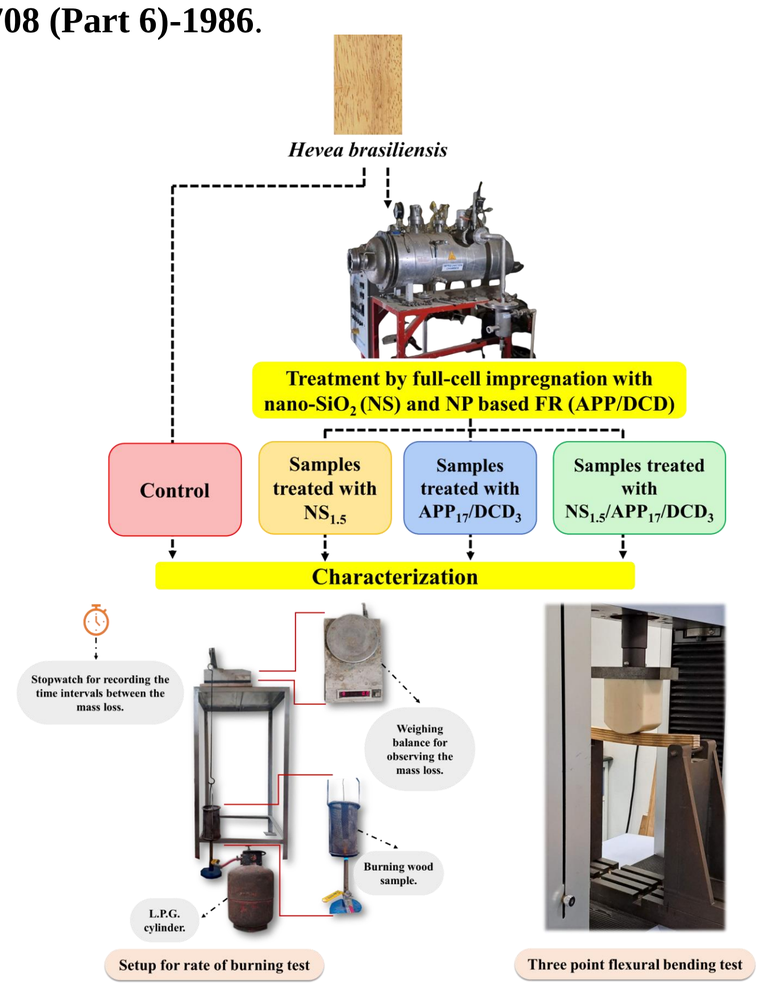

Figure 1: Schematic diagram of the experiment methodology.

References:

1. Kumar, R., & Chauhan, S. (2022). Effect of ammonium polyphosphate as synergist with nano silica dioxide on flammability of boron compound pretreated bamboo flour-HDPE composite. *Fire Safety Journal*, *133*, 103647.

RESULTS & DISCUSSION

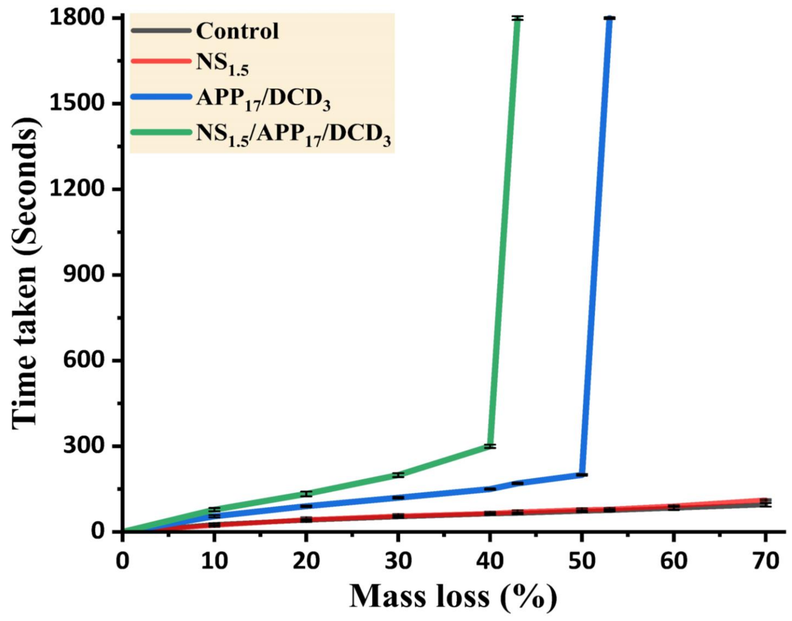

Figure 2: Rate of burning results

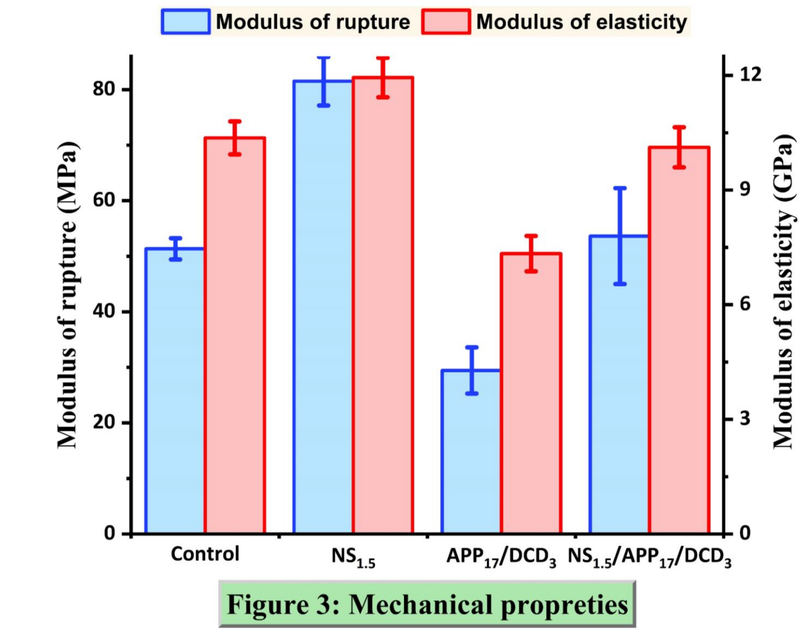

Figure 3: Mechanical propreties

Figure 2 & 3: Results of fire and mechanical properties of treated and control *H. brasiliensis* specimens through rate of burning and flexural bending tests respectively. Error bars given in both the figures represent standard deviation of the mean of six replicates for each treatment.

Rate of burning test results from fig. 2 revealed that the wood samples treated with $NS_{1.5}$ didn't get any significant fire resistance as compared to the control samples, and both failed the test; comparatively the performance of APP_{17}/DCD_3 treated wood was significantly better and it has also passed the test as per the standards. But the $NS_{1.5}/APP_{17}/DCD_3$ treated samples showed most superior fire resistance, which not only passed the test but also showed maximum 40% mass loss even after continuous burning for 30 minutes.

Mechanical results from fig. 3 shows NP based composition: APP_{17}/DCD_3 deteriorates the rigidity and elasticity of wood, but addition of $NS_{1.5}$ enhanced these properties. Moreover, the combined treatment i.e. $NS_{1.5}/APP_{17}/DCD_3$, recovered the wood from mechanical losses caused due to APP_{17}/DCD_3 treatment and made it almost comparable as control.

CONCLUSION & FUTURE WORK

The combination of Nano-SiO_2 with NP based composition: APP/DCD, has thus found to provide excellent synergy in enhancing the fire resistance of *H. brasiliensis* wood while retaining its mechanical integrity.

Future studies can be carried out on investigation of smoke emission and leaching analysis of wood treated with NS/APP/DCD.