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STUDY OF NOISE ISOLATION IN POLYMERIC MATERIALS BASED ON CELLULOSE

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INTRODUCTION & AIM

Noise pollution provoked by vehicles is a growing problem that negatively impacts health for the human. For this reason, it is necessary to explore the possibility of improving sound insulation of some parts of the vehicle, such as commercial automotive paints or panels. Natural fibers has been studied for their good properties of sound absorption and less risk in health than the synthetic fibers in the market [1]. This work deals with studying the incorporation of natural fibers into an acrylic commercial paint. Dispersions of microcrystalline cellulose (C) and nanocellulose (NC), extracted from commercial cellulose, type Iα, obtained by chemical methods (hydrogen peroxide and sodium hydroxide) and acid hydrolysis (sulfuric acid), were prepared at different concentrations (0.1, 1, 3, and 5 wt%). These formulations were applied onto 3003 aluminum substrates and characterized by Raman spectroscopy, X-ray diffraction (XRD), and optical microscopy. Moisture resistance and sound absorption capacity were also evaluated.

METHOD

For this investigation, a commercial white automotive paint was used as the matrix. This paint was combined with different weight percentages (%wt) of cellulose and nanocellulose (0.1, 1, 3 and 5 %). The mixtures were dispersed in an ultrasonic bath 90 minutes and a temperature below 30 °C to ensure homogenization. Then we applied the mixtures in aluminum 3003 alloy boxes (40 x 10 x 10 cm) with thickness of 110 nm for sound pressure measurements. The paint with C and NC were analyzed by Raman spectroscopy, X-ray diffraction (XRD), optical microscopy and moisture resistance.

Figure 1. Paint mixtures on ultrasonic bath.

RESULTS & DISCUSSION

Raman spectra (Figure 2) confirm characteristic cellulose functional groups, reference paint (PR) exhibits signals from TiO_2 pigments: anatase (142 cm⁻¹) and rutile (229, 450, 610 cm⁻¹), plus acrylic-related bands: CCO (1040 cm⁻¹), CH_3 (1163 cm⁻¹), –OH (1300 cm⁻¹), binder (1456 cm⁻¹), carboxyl (1600 cm⁻¹), and esters (1732 cm⁻¹). Paints with cellulose (PC) and nanocellulose (PNC) show no significant spectral changes compared to PR, attributed to the low (3%) particle content.

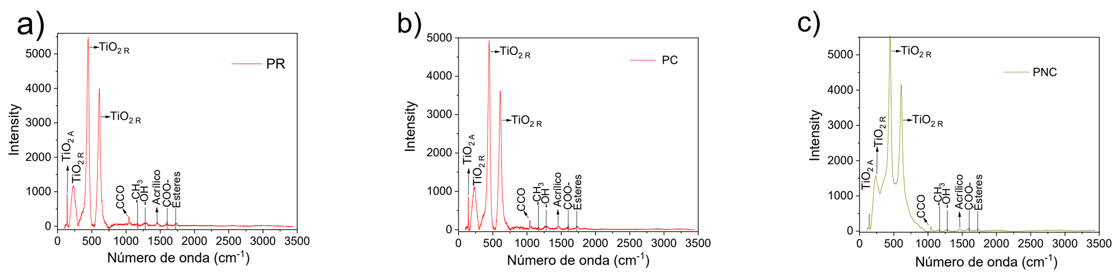

Figure 2. Raman espectra of PR (a), PC (b) and PNC (c).

Cellulose on figure 3 shows planes $(0\bar{1}\bar{1})$, (110), (201) of cellulose Iα (monoclinic) and (200), (004) of cellulose Iβ (triclinic), plus (023) of cellulose II. NC exhibits planes (010), $(\bar{2}\bar{2}2)$, (114) of cellulose II, reflecting its nanocrystalline nature. Paint samples reveal TiO_2 in rutile phase [(110), (101), (200), (111), (210), (211), (220), (310), (112)] and anatase phase [(204), (220)]. No significant changes occur with C/NC addition (≤5%), though weak low-angle signals suggest fiber presence. Acrylic signals are absent due to the amorphous nature of the coating.

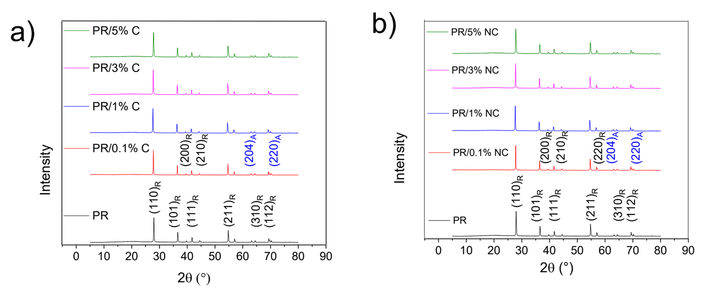

Figure 3. DRX pattern of PR with C (a) and PR with NC (b).

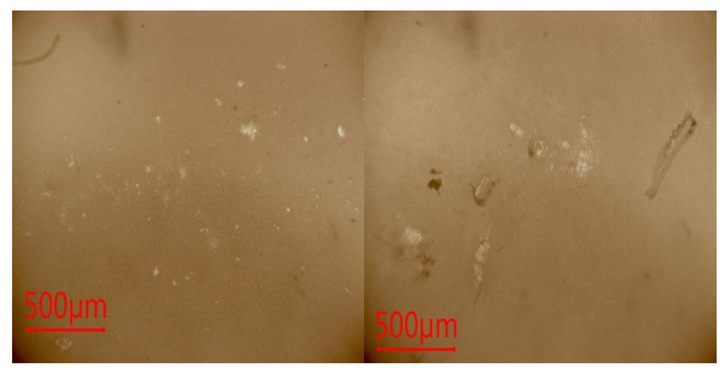

Figure 4. Optical microscopy images of C 5% (left) and NC 5% (right).

Optical microscopy show agglomerates of C and NC at 5× magnification. At 0.1% loading, agglomerates are barely visible, but visibility increases with higher concentrations. At higher magnifications (up to 40×), NC exhibits smaller agglomerates than C, confirming successful extraction of nanoparticles from cellulose microparticles.

In moisture resistance test all samples gained mass after exposure. Higher NC content tends to increase moisture uptake, while low C content improves resistance.

In the sound absorption test PR showed a range of 76.1–82.9 dB. Adding C or NC generally reduced sound levels, except NC 1% (slightly higher minimum).Best performance: C at 5% reduced minimum by 3.15% (2.4 dB) and maximum by 2.05% (1.7 dB).NC at 5% achieved smaller reductions: 1.83% (1.4 dB) minimum and 0.60% (0.5 dB) maximum. Higher C content provides better acoustic attenuation than NC.

CONCLUSION

Raman spectroscopy confirmed the successful chemical extraction of cellulose without structural changes and identified TiO_2 pigments and acrylic components in the reference paint. XRD analysis revealed cellulose as a mixture of polymorphs (types I and II) and confirmed TiO_2 crystalline phases, with no structural changes in the paint after adding C or NC. Optical microscopy showed visible agglomerates of C and fewer, smaller clusters for NC, validating the nanocellulose extraction process. Moisture absorption slightly increased with higher C and NC content but remained close to the reference values. Acoustic tests demonstrated that cellulose provides better sound attenuation than nanocellulose, with the best performance at 5% C addition. The results show us that bigger sized particles have better sound absorption, for future works we recommend to consider another natural fiber for research of a sound absorption paintings.

FUTURE WORK / REFERENCES

1. Yang, T., et al. *Sound Absorption Properties of Natural Fibers: A Review*. Sustainability, 2020. **12**, DOI: 10.3390/su12208477.