THE INFLUENCE OF INCORPORATION OF PULP AND PAPER MILL SECONDARY SLUDGE IN UREA-FORMALDEHYDE RESIN ON MECHANICAL AND PHYSICAL PROPERTIES OF PARTICLEBOARD PANELS

Suying Xing[a], Bernard Riedl[a], Amed Koubaa[b] and James Deng[c]

[a] Centre de recherche sur le bois, Université Laval, 2425 Rue de la Terrasse, Québec QC, G1V 0A6, Canada
[b] Université du Québec en Abitibi-Témiscamingue, 445 boul. de l'Université, Rouyn-Noranda QC, J9X 5E4, Canada
[c] FPInnovations-Forintek Division, 319 rue Franquet, Québec QC, G1P 4R4, Canada

Introduction

Sludge is the final solid waste recovered from the wastewater treatment process in pulp and paper mills. A typical pulp and paper mill water treatment process includes primary treatment and second treatment. The solid residue obtained from primary treatment is called primary sludge (PS). The solid residue obtained from second treatment is called secondary sludge (SS). The most common sludge disposal methods are landfilling, incineration and land application. Because they cause some problems of pollution, the current disposals means need to be improved. On the other hand, the panel industry needs large amounts of resin. In this case, the incorporation of SS in the particleboard would be a beneficial way to recycle this residue and save part of the resin costs.

Experimental

Materials

Sludge collection, drying and grinding

TMP (thermo-mechanical Pulping) mill secondary sludge (SS) was collected from a mill located in Québec city (Québec, Canada). Samples were refrigerated at 4 °C, decanted then dried at 60°C for one week. The dried sludge samples were grounded in roller mill. The milled material was further screened with a 30 mesh sieve and the fraction passed it was collected. The collected materials were used for particleboard fabrication.

Particle preparation

SPF (spruce, pine, fir) particles, with size between 1-5mm, moisture content between 2%-4%, were used for fabrication of the particleboard.

Panel manufacturing and testing

Three particleboard panels were made for each experimental condition: according to a 3^2 factorial design in which factors were urea–formaldehyde (UF) resin amount (5%, 7%, and 9%) and SS amount (75%, 100%, and 125%, dry resin basis). Panel target density was 750 kg/m^3, pressing temperature was 210^{o}C, and pressing cycle time was 6.0 min. Target thickness was 11 mm. Different % of UF, 0.5% emulsion wax, and 0.25% NH_4Cl were mixed and diluted to accelerate cure. Total furnish MC was 12.5%, mats were hand-formed in 500 x 600 mm frame and pressed in a hydraulic press.

All panels were conditioned at 20 ± 3^{o}C and 65% relative humidity. Values of internal bond (IB), modulus of rupture (MOR), modulus of elasticity (MOE) and thickness swelling (TS) were measured in accordance with standard methods of ASTM D 1037-2006a [1] and ANSI A208.1-2009 [2]. An analysis of variance with multiple comparisons was carried out employing Waller-Duncan multiple comparison tests in SAS 9.2.

Results and Discussion

Physical properties

TS values (Fig.1) varied from 14.1 to 63.9%. All panels with SS swelled more than the control panel after 24 hours water soaking. Increasing SS content has a negative impact on TS. It is in agreement with a recent report [3]. Statistic analysis reveals that the effect of SS content is significant in comparison to control panel for each UF's level.

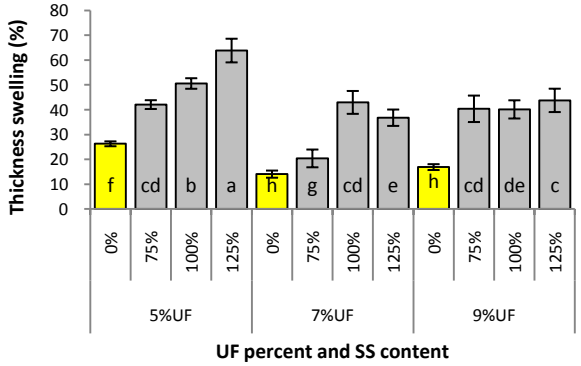

Fig.1. Thickness swell after 24H soaking of particleboard (means with the same letter are not significantly different at the 5% probability level, the following figures are also).

Mechanical properties

The IB values are illustrated in Fig.2. All IB values meet the requirements of M-2 grade particleboard for interior use according to standard [2]. However, the IB values of mixed panels are significantly lower than that of control panel when the UF level is 5%, which is in good agreement with previous reports [3][4]. For the case of 7% UF, addition of 75% SS to panel greatly improves the IB value compared to that of control panel, but when the content of SS is increased to 100% and 125%, the IB values significantly fall compared to that of control panel. For the case of 9% UF, with addition of 75%SS and 100%SS to panel, the IB values of mixed panels significantly fall compared to that of control panel, but with 125% SS added to panel, the IB value is equal to that of control panel.

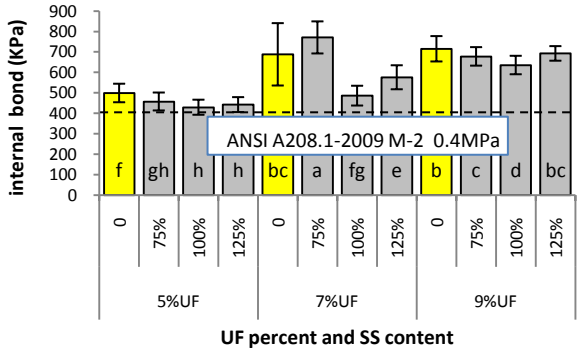

Fig.2. Internal bond strength of particleboard

The MOE values are presented in Fig. 3. All MOE values meet the requirements of M-2 grade particleboard for interior use according to standard [2]. MOE values of mixed panels don't differ significantly with the SS content increase.

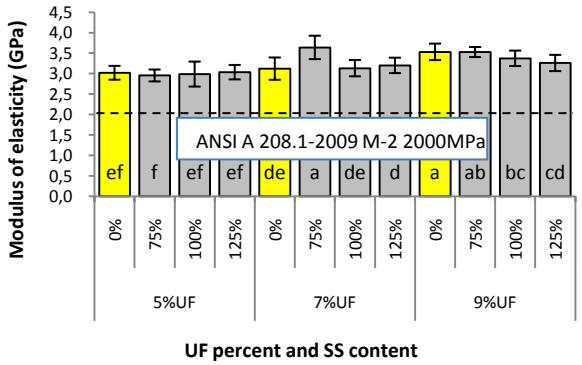

Fig.3. Modulus of elasticity (MOE) of the particleboard

The MOR values are presented in Fig. 4. When the UF level is 5%, MOR values are inferior to the requirement except the value of control panel. In general, the MOR of the boards decreases as the SS content increase. The reason for this behavior is attributed to the weak adhesion between the SS and wood particles because of the inorganic materials in the paper sludge.

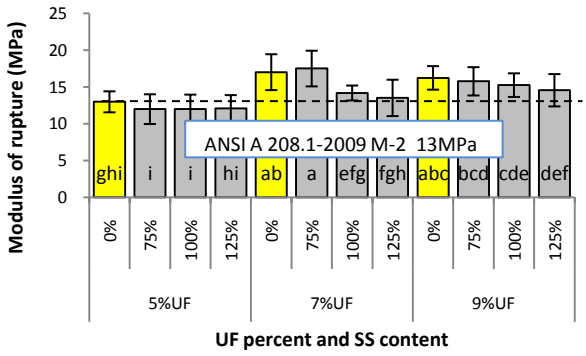

Fig.4. Modulus of rupture (MOR) of the particleboard

Conclusion

The results of this study indicate that, in general the properties of the produced particleboards are negatively affected by the use of secondary sludge. But there is a special case: the board made from 7% UF with 75% SS is better than the control panel. As a result, the board made from 7% and 9% UF with different % of SS satisfied fully the requirements set by standards [2] for general uses. From the point view of savings, using 7% UF will be a wise choice. Still, dimensional stability is negatively affected by the SS.

References

1.Standard test methods for evaluating properties of wood-base fiber and particle panel materials. ASTM D 1037-2006a (2006).

2.ANSI Particleboard ANSI A208.1 -2009. American National Standard Institute, Composite Panel Association, Leesburg, VA. (2009)

3.Migneault S., Koubaa A., Nadji H., Riedl B., Zhang S. Y. and Deng J. Medium-density fiberboard produced using pulp and paper sludge from different pulping processes. Wood Fiber Sci., **42**(3) (2010) 292-303.

4.Taramian A., Doosthoseini K., Mirshokraii S.A., Faezipour M.. Particleboard manufacturing: An innovative way to recycle paper sludge. Waste Manag **27**(2007) 1739-1746.