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Review on the Manufacture of Particleboard from Agro-Wastes Using Different Adhesives

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THE RISING concern towards environmental issues and on the other hand, the need for more versatile polymer–based materials has led to increasing interest about polymer composites filled with natural-organic fillers coming from renewable and biodegradable sources. This review illustrates the main paths and results of researches for manufacturing of particleboard from agro wastes using different synthetic and natural adhesives,as well as appropriate references for further in-depth studies.

Keywords: Particleboard,Composites, Rice straw, Ureaformaldehyde resin, Poly (methylenediphenyl diisocyanate), Polypropylene and Polyethylene, Soyaprotein adhesive, Polylactic acid adhesives and Starch adhesive.

Building materials used in sustainable design[1,2] usually undergo an extensive network of extraction, processing, and transportation steps required in their creation. Building green helps minimize pollution, protect the natural environment and create a healthy, comfortable, non-hazardous place to live and work. For maximum benefit, a building's design and the materials used in that design, need to be appropriate to the site and its geographic location. There are several challenges to using natural materials in the building of a structure. Reusing materials instead of dumping them in landfills can save valuable resources and actively seeking out and buying products with recycled content can help the environment.

Particleboard and fiberboards in the medium-density range are widely used for construction, furniture and interior decoration (wall and ceiling paneling). The main lignocellulosic raw material used in the particleboard and fiberboard industry is wood, but other agro-based residues have recently frequently utilized. Annual plant waste such as flax and hemp shives, bagasse, cotton stalks, small grain straw (including rice straw), peanut husks, rice husks, grape stalks and palms stalks are inexpensive and valuable raw materials for lignocellulosic board production. The production of panel products from agricultural residues is important considering the increasing worldwide wood fiber shortage.

The particleboard industry relies extensively on adhesives that account for up to 32% of manufacturing costs in the glued-wood composites industry.

The adhesives used in wood composites mainly depend on either synthetic or natural ones.

Scientific Background

Synthetic resins

A lot of synthetic resins [3] are used as a binder for straw to manufacture high performance fiberboards.

Urea formaldehyde resin (UF)

UF is the most known synthetic resin mainly used as a binder for rice straw. The synthesis of a UF resin proceeds via the methylolation of urea and condensation of the methylol groups[4] . The production of UF resins is achieved in various stages and special additives are used to improve the conditions. Three-dimensional networks are constructed during curing of urea and formaldehyde initiated at lower pH. The curing is monitored by thermal methods and spectroscopic measurements. The pH values in UF formulations have a significant influence on the rate constants. The curing of urea/formaldehyde resins releases formaldehyde into the environment.

Manufacturing dry-formed rice straw medium density fiber board (RSMDF) using UF resin by mechanical technique without pretreatment technique was investigated[5]. The properties and the quality of the produced (RSMDF) fiberboard were evaluated. They revealed that they depend on the average density and the resin contents. The RSMDF panels were produced successfully using the new rice straw fibers preparation technique and their properties met the requirements of MDF standard.

Rice straw-wood particle board composite for sound absorbing wooden construction materials, using UF as a binder was manufactured by Yang, H.S. *et al* [6].

Effect of oxalic acid (OA) and steam pretreatment on the primary properties of UF-bonded rice straw particleboards was evaluated [7,8]. It showed that steam- and short durations of OA-treatment significantly improved the mechanical properties and dimensional stability of rice straw particleboards. However, steam-treated rice straw (without OA-treatment) panels exhibited even better performance when compared with OA-treated panels. OA-pretreatment time has a negative effect on performance of panels, whereas the effect of temperature on the performance of OA-treated panels was not significant, except for the linear expansion.

Improvement of rice straw surface characteristics via thermo mechanical and chemical treatment was investigated[9]. Acid treatment dissolves hemicelluloses significantly, leading to more fines and more voids in the surface of the rice straw fibre. The fines showed a higher water retention value (WRV) of 137.41% and exhibited higher swelling capacity. An increase in acid loading resulted in the increased (WRV).

Li, X. *et al*. [(10)] evaluate the primary mechanical and physical properties of particleboard made from hammer-milled rice straw particles of six different categories using UF resin. The results show the performance of straw particleboards is highly dependent upon the straw particle size, controlled by the opening size of the perforated plate inside the hammer-mill.

Surface characteristics of overlaid medium density fiberboard (MDF) panels manufacture from rice straw and bamboo using UF resin as a binder were evaluated[(11)]. It shows that both non-wood under-utilized species can be considered as raw material to manufacture value-added MDF panels as substrate for overlaying without having any adverse influence on their surface quality.

In order to manufacture straw based panel with high quality, low toxic and fire retardant[(12)] , the interface of wheat-straw, before binding with UF resin was treated with alkaline liquid. The conductivity and diffusion coefficient K of the straw material after alkaline liquid treatment increased obviously. This indicated that alkaline liquid treatment improved the surface wet ability of straw, which is helpful for the infiltration of resin. The physical and mechanical properties of wheat-straw boards after treated increased remarkably and it could satisfy the national standard. The improvement of the straw surface wet ability is helpful to the forming of chemical bond.

The properties of medium-density fibreboard (MDF) based on wheat straw and melamine modified urea formaldehyde (UMF) resin a fully equipped pilot-plant was studied [(13)]. The properties of the resulting SMDF were evaluated by analyzing mechanical and water absorption (anti-swelling) properties.

The potential for using walnut shell as a raw material for wood-based particleboard manufacturing was investigated [(14)]. The boards had lower thickness swelling and water absorption, so they can be used for outdoor environment.

The influence of relative humidity on surface quality and adhesion strength of coated medium density fiberboard (MDF) panels using wood particles was studied[(15)]. Overall adhesion strength characteristics of the panels samples were adversely influenced by increased value of relative humidity exposure.

Phenol – formaldehyde (PF) adhesive

Mechanical and physical properties of wheat straw boards bonded with a tannin modified phenol-formaldehyde adhesive were investigated[(16)], it revealed that wheat straw can be used as a promising raw material for panel production with the use of a tannin-modified PF adhesive.

Polymeric methylendiphenyl diisocyanate (PMDI)

PMDI is of particular interest for rice straw particleboard manufacturing[3, 17] because of its ability to bind rice straw despite the wax present on the surface of the straw. Advantages of the diisocyanates include their high reactivity, high binding quality for exterior-grade panel products, and no formaldehyde release. However, the disadvantages of diisocyanates include their relatively higher price and higher toxicity of the uncured glue than other adhesives.

The effect of PMDI and UF resin content on the mechanical and fire retardant property of straw[12] based panels with surface alkali processing was investigated. Compared with PMDI –bonded panels, the rice straw particle board bonded using UF resin exhibits much poorer performance.

Li , X. *et al.* evaluated the primary mechanical and physical properties of particle board made from hammer milled rice straw particles and two types of resins (UF and PMDI)[10].

A less expensive and environmentally friendly rice bran adhesive may be used to replace a portion of PMDI and still give high. *T* quality products.[17] Rice bran adhesive (RBA) was used to replace 10,20, and 30% of PMDI adhesives. The properties of the resulting mixed adhesive products were then evaluated and compared with particleboard bond with only PMDI. Up to 30% of the PMDI could be replaced with RBA to yield products with properties similar to those of PMDI bond particleboard.

Polypropylene (PP) and polyethylene (PE)

Effects of nanoparticles (silica and clay) on the mechanical properties of rice straw/polypropylene composites have been studied [18]. Generally high amount of nano-size particles in the composites can lead to the reduction of interfacial adhesion between matrix polymer and filler, and it limits their applications. Transmission electron microscopy revealed the existence of uniform, intercalated nanoclay dispersed throughout the matrix. At 1 and 2 wt% loading the mechanical properties of composites filled with nanoclay are general greater than nanosilica composites.

Whole and split wheat straws (WS) with polypropylene (PP) webs to make lightweight composites with properties superior to jute-PP composites with the same density were investigated[19] . The effect of WS concentration, WS length, split configuration, and mechanically split on flexural and tensile properties of the composites has been investigated. The sound absorption properties of composites from whole straw and split straw have been studied. Compared with whole WS-PP composites mechanically split WS-PP composites have higher flexural strength, modulus of elasticity, impact resistance properties, tensile strength, Young's modulus. Compared with jute-PP composites, mechanically split WS-PP composites have higher flexural strength, modulus of elasticity, tensile strength, and Young's modulus, better sound absorption properties and lower impact resistance.

Bledzki, A.K. *et al.* studied[20] the potential of grain by-product such as barely husk coconut shell as reinforcements thermoplastic (polypropylene PP) as an alternative or together with wood fibers. Thermal degradation characteristics of those fibres, particle morphology and particle size were investigated. Also, water absorption properties, chemical composition and surface chemistry of those fibres were also determined to evaluate their importance in determining the end-use properties of composites.

The physico-mechanical properties of chemically treated coir reinforced PP composites have been investigated[21]. In order to attain improved mechanical properties of the composites, coir was chemically treated with o-hydroxy benzene diazonium salt. Both raw and treated coir samples were utilized for the fabrication of the composites. The mechanical properties of the composites prepared from chemically treated coir are found to be much better compared to those of untreated ones.

Development of high density polyethylene (HDPE)/rice straw composite for construction application via injection mold technique was investigated [22]. The higher the rice straw content the less thermally stable the biocomposite becomes and the lower is the melting point. Thermal behaviour also indicated that the suitability of processing HDPE/rice straw biocomposite is below 200^{o}C depending on the rice straw composite.

Effect of fiber type and loading on rice straw-fiber-reinforced high density polyethylene composite was investigated [23]. The rice straw fiber systems had comparable mechanical properties with those of wood composites. Increase in fiber loading led to increased moduli and decreased tensile and impact strength.

Withdrawal strength of strength of fasteners in rice straw fiber-thermoplastic composite polyethylene-polypropylene (PEPP) under dry and wet conditions was studied [24]. It showed that the withdrawal strength of screws is more than that of nails. Also, irrespective of the type of polymer, the percentage of rice straw fiber may significantly influence the withdrawal strength of fasteners, especially at the higher fiber to polymer ratios. Furthermore, it was found that in the wet condition the withdrawal strengths of the nail fasteners are reduced more (73.66%) than for the screws (28.9%).

Polyvinyl alcohol and polystyrene adhesive

Mechanical properties of rice straw fiber-reinforced polymer composites based on polyvinylalcohol and polystyrene polymers with different ratios were studied.[25]. The results indicated that, flexural strength, impact strength and modulus of elasticity increase with increasing the polymer ratio in the mix composition. The water absorption and thickness swelling percentages of rice straw fiber polystyene composites decrease with increasing the polystyrene content, while their values for rice straw polyvinyl alcohol composites improve.

Polyvinyl chloride

Wood plastic composites (WPCs) were developed from rice hull and poly (vinyl chloride) (PVC)[26] . The influences of the rice hull particle size and content on the mechanical properties and the visual appearance of the WPC decking board were investigated. The experimental results revealed that the impact strength tended to decrease with increasing rice hull content. The composites with larger particle sizes exhibited higher impact strength. Under tensile and flexure load, higher rice hull content induced greater modulus and ultimate strength. The smaller particles of the milled rice hull, the greater tendency for them to act as a pigment to form a darker shade.

Poly (hydroxyl butyrate cohydroxyvalerate) (PHBV) copolymer

Mechanical rice straw filled composites were prepared from poly (hydroxybutyrate-co-hydroxyvalerate) (PHBV) copolymer containing 13% mole hydroxybutyrate. The effect of rice straw content on thermal and mechanical properties of the composites was investigated[27]. It was shown that the value of tensile modulus value almost doubled with the increase of rice straw content, while the tensile strength slightly decreased, compared to pure PHBV resin. PHBV/RS composites are expected to be developed as materials for structure applications, especially for panelized components with good thermal insulation, intended for improvement of the energy efficiency in eco-buildings.

Novel green composites were successfully fabricated by incorporating agro-residues as corn straw (CS), soy stalk (SS) and wheat straw (WS) into the bacterial polyester, poly (3-hydroxybutyrate-co-3-hydroxyvalerate), PHBV, by melt mixing technique[28]. Effects of these biomass fibers on mechanical, thermal, and dynamic mechanical properties of PHBV were investigated. A comparative study of biomass fiber-reinforced polypropylene composite systems was performed. For equal amounts of (30%) biomass fibers, tensile and flexural modulii of PHBV composites showed much higher values than corresponding PP composites. Alkali treatment of wheat straw fibers enhanced strain at break and impact strength of PHBV composites by ~ 35%, hardly increasing strength and modulus compared to their untreated outcomes.

Recycled plastics and resin

Water-resistant panels were manufactured from recycled plastics and resin [29] obtained from food, perfumery or cleaning packaging, waste production from factories due to failures in sheet thickness. This contributes to decontaminating the environment, since most of these wastes are buried in municipal land without any use, or accumulated and burned in landfills, causing environmental degradation.

Natural adhesives

Replacing a part or all of the currently used synthetic adhesives with inexpensive and environmentally friendly adhesives is of interest to the particleboard industry.

Soyaprotein adhesive

Among several natural products, high protein containing soybean is finding use in particleboard industry[30,31] . However, due to its low water resistance and adhesive strength soy protein-based adhesives have not been accepted early in the marketplace. Myers[30] determined that bleached wheat straw particleboard bond with soyabean-based adhesive had similar or better mechanical strength than that with urea formaldehyde resins. The advantage of being formaldehyde free which makes them a suitable alternative for indoor applications. They also have high flexural strength.

The possibilities of using soy protein isolate (SPI) and wheat gluten (WG) as binders for particle boards were studied by Khosravi ,S. *et al.*[32] .

The effects of carbohydrates on the water resistance and bonding strengths of soy-based adhesives (SBAs) were studied[33] .

Polylactic acid natural filler adhesive

Natural fiber reinforced poly (lactic acid) (PLA) composites have received great attention [34]. However, the poor interfacial adhesion between strong polar natural fibers and the non-polar PLA matrix limited its applications. Rice straw fiber (RSF) was pre-treated to improve its compatibility with PLA. Methyl methacrylate (MMA) was selected as the monomer in the admicellar polymerization for the RSF treatment, because RSF coated with poly (methyl methacrylate) (PMM) thin film would have better compatibility with the PLA matrix. The results confirmed that the thermal stability of treated TRSF-PLA was improved compared with RSF-PLA composite.

Another study for using PLA for the manufacture of particleboard was carried out[35]. The PLA-Rice straw fiber composites with various content ratios were prepared by using an internal mixer and a flatten press. The thermal properties, interface effect and mechanical performance measurement, TG, DSC and SEM technique were studied. It was found that increasing the content of rice straw fiber leads to the decrease of the melting temperature. Introducing the rice straw fibers into PLA matrix does not result in any enhancement of mechanical property. However, the tensile strength of the composite increases as the content of rice straw fiber increases from 10% to 30%. The interface effect between fibers and PLA was obviously observed by SEM photo. It was thought such an issue could be improved by the addition of appropriate coupling agents into the composites.

Biodegradalole composites[36] were prepared from modified rice straw fiber (MRSF), Polybutyl acrylate (PBA) and PLA. The tensile strength of PLA/MRSF increased by 6 MPa. Compared with blank sample and water absorption is lower than unmodified sample. The thermal stability increased with PBA increasing.

Natural rubber latex

Biodegradable and easily disposable natural rubber latex jute composite was prepared [37] in order to have acoustical and fire-retardant properties.

Starch adhesive

Attempts have also been made to use starch-based adhesives in particleboard systems.

Environmentally sounds composites [38, 39] were produced from rice straw and corn starch. They have high flexural strength. The developed composite have potential application for ceiling panels and bullet in boards.

The physical and mechanical properties of particleboard made from rubber wood using modified starch as binder were evaluated[40] .

The performance of cornstarch and tannin in phenol-formaldehydes for plywood production was investigated[41]. The performance of these panels is comparable to those of plywood panels made from commercial phenol formaldehyde.

References

1. **Kubba, S.,** *Green Construction Project Management and Cost Oversight*, Chapter 6- Choosing materials and products, Elsevier Store , Americas, 221-226 (2010).

2. **La Mantia, F.P. and Morreale, M.,** Green composites, *Applied Science and Manufacturing* ,**42**, 579-588 (2011).

3. **Mo, X., Cheng, E., Wang, D. and Sun, X. S.,** Physical properties of medium–density wheat straw particleboard using different adhesives. *Industrial Crops and Products*, **18**, 47-53 (2003).

4. **Fink, J.K.,** *Reactive Polymers Fundamentals and Applications*, *Urea /Formaldehyde Resins*, (2ndedition), Elsevier, Montanuniversitat Leoban, Austria, 179-192 (2013).

5. **El-Kassas, A.M. and Mourad, A.H.I.,** Novel fibers preparation technique for manufacturing of rice straw based fiberboards and their characterization. *Materials & Design*, **50**, 757- 765 (2013).

6. **Yang, H.S., Kim, D.J. and Kim, H.J.,** Rice straw- wood particle composite for sound absorbing wooden construction materials. *Bioresource Technology*, **86**, 117-121 (2003) .

7. **Li, X., Cai, Z., Jerrold, E., Winandy, J.E. and Basta, A.H.,** Effect of oxalic acid and steam pretreatment on the primary properties of UF- bonded rice straw particleboards. *Industrial Crops and Products*, **33**, 665-669 (2011).

8. **Li, X., Wu, Y., Cai, Z. and Winandy, J.E.,** Primary properties of MDF using thermomechanical pulp made from oxalic acid pretreated rice straw particles. *Industrial Crops and Products*, **41**, 414-418 (2013).

9. **Pan, M., Zhou, D., Zhou, X. and Lian, Z.,** Improvement of straw surface characteristics via thermomechanical and chemical treatments. *Bioresource Technology*, **101**, 7930-7934 (2010).

10. **Li, X., Cai, Z., Winandy, J.E. and Basta, A. H.,** Selected properties of particleboard panels manufactured from rice straws of different geometries. *Bioresource Technology*, **101**, 4662-4666 (2010).

11. **Hiziroglu, S., Jarusombuti, S., Bauchongkol, P. and Feunagvivat, V.,** Overlaying properties of fiberboard manufactured from bamboo and rice straw. *Industrial Crops and Products*, **28**,107-111 (2008).

12. **Zhu, X.D., Wang, F.M. and Liu, Y.,** Properties of wheat-straw boards with frw based on interface treatment. *Physics Procedia*, **33**, 430-443 (2012).

13. **Halvarsson, S., Edlund, H. and Norgen, M.,** Properties of medium-density fibreboard (MDF) based on wheat straw and melamine modified urea formaldehyde (UMF) resin. *Industrial Crops and Products,* **28**, 37-46 (2008).

14. **Pirayesh, H., Khazaeian, A. and Tabarsa, T.,** The potential for using walnut (*Juglans regia* L.) shell as a raw material for wood-based particleboard manufacturing. *Composites Part B: Engineering*, **43**, 3276-3280 (2012).

15. **Ozdemir, T., Hiziroglu, S. and Malkocoglu, A.,** Influence of relative humidity on surface quality and adhesion strength of coated medium density fiberboard (MDF) panels. *Materials, & Design*, **30**, 2543 -2546 (2009).

16. **Tabarsa, T., Jahanshahi, S. and Ashori, A.,** Mechanical and physical properties of wheat straw boards bonded with a tannin modified phenol-formaldehyde adhesive. *Composites Part B: Engineering*, **42**, 176-180 (2011).

17. **Pan, Z., Cathcart, A. and Wang, D.,** Properties of particleboard bond with rice bran and polymeric methylene diphenyl diisocyanate adhesives. *Industrial Crops and Products*, **23**, 40-45 (2006).

18. **Ashori, A.,** Effect of nanoparticles on the mechanical properties of rice straw / polypropolene composites. *Journal of Composite Materials*, **47**, 149-154 (2013).

19. **Zou, Y., Huda, S. and Yang, Y.,** Lightweight composites from long wheat straw and polypropylene web. *Bioresource Technology*, **101**, 2026- 2033 (2010).

20. **Bledzki, A.K., Mamun, A.A. and Volk, J.,** Barley husk and coconut shell reinforced polypropylene composites: The effect of fibre physical, chemical and surface properties. *Composites Science and Technology* , **10**, 840-846 (2010).

21. **Islam, Md.N., Rahman, Md. R., Maque, M. and Huque, Md. M.,** Physico-mechanical properties of chemically treated coir reinforced polypropylene composites. *Composites (Part A)*, **41**, 192-198 (2010).

22. **Nurnadia, A., Intan M.D., Rohman, W.A., Aizan, W. and Hanizam, S.,** Development of HDPE / rice straw composite for construction application via injection mold

technique. *National Symposium On Polymeric Materials, University Kuala Lumpur* , November 27-28 (2007).

23. **Yao, F., Wu, O., Lei, Y. and Xu, Y.,** Rice straw fiber-reinforced high-density polyethylene composite: Effect of fiber type and loading. *Industrial Crops and Products*, **28**, 63-72 (2008).

24. **Madhoushi, M., Nadlizadeh, H. and Ansell, M.P.,** Withdrawal strength of fasteners in rice straw fibre-thermoplastic composites under dry and wet conditions. *Polymer Testing*, **28**, 301-306 (2009).

25. **Ismail, M.R., Yassen, A.A.M. and Afify, M.S.,** Mechanical properties of rice straw fiber-reinforced polymer composites. *Fibers and Polymers* , **12**, 648-656 (2011).

26. **Petdrwattana, N. and Covavisaruch, S.,** Effects of rice hull particle size and content on the mechanical properties and visual appearance of wood plastic composites prepared from poly vinyl chloride. *Journal of Bionic Engineering*, **10**, 110-117 (2013).

27. **Buzarovska, A., Bogoeva, G., Grozdanov, A., Avella, M., Gentile, G. and Errico, M.,** Potential use of rice straw as filler in eco-composite materials. *Australian Journal of Crop Science*, **1**, 37-42 (2008).

28. **Sandeep, S.A., Mohanty, A.K. and Mirsa, M.,** Mechanical behavior of agro-residue reinforced poly (3-hydroxybutyrate – co-3-hydroxyvalerate) (PHBV) green composites: A comparison with traditional polypropylene composites. *Composites Science and Technology*, **71**, 653-657 (2011).

29. **Gaggino, R.,** Water –resistant panels made from recycled plastics and resin. *Construction and Building Materials*, **35**,468 – 482 (2012).

30. **Myers, D.,** Industrial applications for soy protein and protein products for increased utilization. *Cereal Foods World*, **38** (5), 355-360 (1993).

31. **Ciannamea, E.M., Srefani, P.M. and Ruseekaite, R.A**., Medium–density particleboards from modified rice husks and soybean protein concentrate- based adhesives. *Bioresource Technology*, **101**, 818-825 (2010).

32. **Khosravi, S., Khabbaz, F., Nordqvist, P. and Johansson, M.,** Protein- based adhesives for particleboards. *Industrial Crops and Products*, **32**, 275-283 (2010).

33. **Chen, N., Lin, Q., Rao, J. and Zeng, Q.,** Water resistance and bonding strengths of soy-based adhesives containing different carbohydrates. *Industrial Crops and Products*, **50**, 44-49 (2013).

34. **Zhao, Y., Qiu, J., Feng, H., Zhang, M., Lei, L. and Wu, X.,** Improvement of tensile and thermal properties of poly(lactic acid) composites with admicellar-treated rice straw fiber. *Chemical Engineering Journal* , **173**, 659-666 (2011).

35. **San, D., Sung, W.P. and Chen, R.,** Preparation and characterization of PLA/ rice straw fibercomposit. *Applied Mechanics and Materials*, **71**, 1154-1157 (2011).

36. **Qin, L., Qiu, J., Liu, M., Ding, S., Shao, L., Lu, S., Zhang, G., Zhao, Y. and Fu, X.,** Mechanical and thermal properties of poly(lactic acid) composites with rice straw fiber modified by poly (butylacrylate*). Chemical Engineering Journal*, **166**, 772-778 (2011).

37. **Fatima, S. and Mahanty, A.R.,** Acoustical and fire-retardant properties of jute composite materials. *Applied Acoustics*, **72**, 108-114 (2011).

38. **Liu, J., Jia, C., Jra, C. and He, C.,** Rice straw and cornstarch biodegradable composites, *AASRI Procedia*, **3**, 83-88 (2012).

39. **Liu, J., Jia, C., Jra, C. and He, C.,** Flexural properties of rice straw andstarch composites. *AASRI Procedia*, **3**, 89-94 (2012).

40. **Amini, M.H.M., Hashim, R., Hiziroglu, S., Sulaiman, N.S. and Sulaiman, O.,** Properties of particleboard made from rubberwood using modified starch as binder , *Composites Part B, Engineering* , **50**, 259-254 (2013).

41. **Moubarik, A., Pizzi, A., Allal, A., Charrier, F. and Charrier, B.,** Cornstarch and tannin in phenol-formaldehyde resins for plywood production. *Industrial Crops and Products*, **30**, 188-193 (2009).

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مقالة مرجعية فى تصنيع الواح الخشب الصناعى من النفايات الزراعية باستخدام انواع مختلفة من المواد الرابطة البوليمرية

راجيـــة محمـــود محسن ، فـوزيـة فهيـم عبد المحسن ، نــهى الــدغيــدى* و يسرية مصطفى أبو عيانة
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يهدف هذا البحث المرجعي إلي تجميع طرق الإستفاده من المخلفات الزراعيه الطبيعيه وذلك بتحريلها إلي منتجات صناعيه تطبيقيه مفيده مثل الخشب الحبيبي والأخشاب الصناعيه MDF والتي لها تطبيقات عديده خاصه في المجالات الإنشائيه والديكوريه. ويتم ذلك بخلط هذه المخلفات مع بوليمرات مختلفه طبيعيه أو مخلقه.

ومن أمثلة البوليمرات التي يمكن إستخدامها في هذه التطبيقات بوليمرات اليوريا فورمالدهيد والفينول فورمالدهيد وهي بوليمرات متصلبه بالحرارة ويتم خلطها بنسب مختلفه مع مخلفات قش الأرز وإنتاج أنواع من الخشب الحبيبي عالي الجودة ذو خواص طبيعيه وميكانيكيه ممتازه.

كما يمكن إستخدام بوليمر الميثيلين داي فينيل داي أيزوسيانات إذ أن هذا البوليمر يعطي ألواح الخشب الناتجة خاصيه مقاومه الحريق.

من البوليمرات المستخدمه أيضا البولي بروبيلين والبولي إيثيلين عالي الكثافه حيث تستخدم كماده رابطه لمخلفات الذرة والأرز وينتج منهما متراكبات خشبيه بوليمريه خفيفه الوزن ذات خواص فائقه.

كما يمكن أيضا إستخدام مجموعة البوليمرات الفينيليه مثل البولي فينيل الكحول والبولي ستايرين والبولي فينيل كلورايد وذلك في إنتاج متراكبات بوليمريه عاليه الجوده.

أما البوليمرات الطبيعيه المستخدمه في هذا المجال فمن أمثلتها بروتين الصويا والبولي لاكتيك ومستحلب المطاط الطبيعي وغراء النشا الطبيعي.