Chapter 4

Natural Adhesives, Binders, and Matrices for Wood and Fiber Composites: Chemistry and Technology

Antonio Pizzi
Lorraine University, Epinal, France & King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT

Recent developments and trends in the field of bio-based adhesives are reviewed. The more recent developments in tannin adhesives without the use of aldehyde-yielding compounds under the conditions of processing, or even without the use of hardeners, are described. Lignin adhesives are discussed next. The combination of these two types to yield natural environmentally friendly matrices for non-woven fiber mats is also reviewed. Several new trends in the developments of protein adhesives and in carbohydrate adhesives are then addressed. Unsaturated oil adhesives based on epoxidized unsaturated vegetable oils are also described as well as an example of cashew nut shell oil modified by a new and inexpensive method to yield an adhesive by self-condensation of the material. The chapter addresses last the new process of solid wood friction welding without the use of adhesive, in which the wood interface itself is used as the binder.
INTRODUCTION

Wood and fiber adhesives from renewable raw materials have now been a topic of considerable interest for many years. This interest, already present since the 1940s, became more intense with the world’s first oil crisis in the early 1970s and subsided again as the cost of oil decreased. At the beginning of the 21st century this interest is becoming intense again for a number of reasons. The foreseen future scarcity of petrochemicals still appears to be reasonably far into the future. It is a contributing factor but, at this stage, it is not the main motivating force. The main impulse of today’s renewed interest in bio-based adhesives is the acute sensitivity of the general public to anything that has to do with the environment and its protection. It is not even this concern per se that motivates such an interest. There are rather very strict, for some synthetic adhesives almost crippling, government regulations which are just starting to be put into place to allay the environmental concerns of the public.

First of all, it is necessary to define what is meant by bio-based wood adhesives, or adhesives from renewable, natural, non-oil-derived raw materials. This is necessary because in its broadest meaning the term might be considered to include urea-formaldehyde resins, urea being a non-oil derived raw material. This of course is not the case. The term “bio-based adhesive” has come to be used in a very well specified and narrow sense to only include those materials of natural, non-mineral, origin which can be used as such or after small modifications to reproduce the behavior and performance of synthetic resins. Thus, only a limited number of materials can be currently included, at a stretch, in the narrowest sense of this definition. These are tannins, lignin, carbohydrates, unsaturated oils, proteins and protein hydrolysates, dissolved wood and wood welding by self-adhesion. To this in the future will surely be added proteins, blood and collagen being already used to some extent on technology from the far past. The bio-based wood adhesives approach does not mean, however, to go back to the technology of natural product adhesives as they existed up to the 1920s and 1930s before they were supplanted by synthetic adhesives. The bio-based adhesives of which we are talking about here are yes derived from natural adhesives, but using or requiring novel technologies, formulations and methods.

Of the classes of bio-based wood adhesives mentioned above, in the case of tannins and lignins their interest has been directed primarily at substituting phenol-formaldehyde (PF) resins, because of the phenolic nature of these two classes of compounds. In some cases, some formaldehyde is still used, and in the case of lignin some other additives. It is then necessary to distinguish between bio-based adhesives in which a limited amount of synthetic additives are still used, and bio-based wood adhesives where no synthetic additives are used.
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