

专家特稿

CHEMICAL UTILIZATION OF FOREST PRODUCTS IN CHINA*



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Abstract: Chemical utilization of forest products is referred to the chemical processing of both wood and non-wood forest raw materials to produce various products, necessary to the development of national economy. The main products are: wood pulp and paperboard, wood-based active carbon, oleoresin chemicals, vegetable tannins, essential oils, plant extracts, etc. In recent years, Chinese forest chemical industry developed rapidly, especially the construction of integrated forest-paper industry provides the favorable conditions for the development of wood pulping industry and the change of the raw material structure for Chinese paper industry. According to the plan, the wood pulp output in 2005 will be 3.8 million tons and 7.5 million tons in 2010. The annual output of gum rosin in China has already been over 500 kt with annual export of around 300 kt. The wood-based active carbon output is about 60 kt/a. With the development of Chinese economy, the demand for the forest chemical processing products is expected to keep increasing.

Key words: forest products; chemical industry

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中国林产品化学利用概况

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摘 要: 林产品化学利用是指以木质和非木质林产品为原料, 经化学加工制备国民经济所需的各种产品。主要包括木材制浆造纸、木质活性炭、松脂化学加工、植物单宁、林产精油、植物提取物等。近年来中国林产化学工业发展较快, 特别是建设林纸一体化工程, 为发展木材制浆工业, 改变中国制浆造纸工业原料结构创造了良好的条件, 按计划 2005 年木浆产量将达 380 万 t, 2010 年达 750 万 t。松香产量已超过 50 万 t/a, 出口约 30 万 t/a。木质活性炭产量达 6 万 t/a。随着我国经济的发展对林化产品的需求将进一步扩大。

关键词: 林产品; 化学工业

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Chemical utilization of forest products, both wood and non-wood forest products, is one of the important fields for effective and sustainable utilization of forest resources, and also an important part of forest product industry. In this category, there are two groups of products based on the raw material used. The first includes the wood chemical products, which are produced by chemical processing of woody raw material, such as logs, chips and sawdust. The important products of this group are wood pulp, paper and paperboard, charcoal and wood-based active carbon. The second group is non-wood forest chemical products, which are produced by chemical processing of non-wood forest resources, i. e. leaves, barks, exudates, fruits, seeds and flowers, as well as various undergrowth plants in forest areas. The main products of this group are gum rosin, turpentine, tannin extracts, tannic and gallic acids, shellac, various essential oils and biologically active substances for pharmaceutical preparations as well as a series of products developed by further processing. These products are widely used in the chemical, food, pharmaceutical, light and other industries^[1-2].

Chemical utilization of forest products has been developed in China for many years. At present the industry covers more than 1 000 factories of various production capacities and produces annually about 2 million tons wood pulp, 400- 500 kt gum rosin, 60- 70 kt turpentine oil, 60 kt wood-based active carbon, 10 kt vegetable tannins as well as 10 kt essential oils and plant extracts.

1 Wood pulping and papermaking

With the development of the national economy and the living standard of people, the pulp and papermaking industry rapidly developed in China in past twenty years. Now China ranks the second in the world in production and consumption of pulp and paper products. In 2002, the total output of paper and paperboard in China was 37. 8 million tons and the consumption of the products was 43. 32 million tons. However, the per capita consumption of the paper and paperboard is only about 33 kg, taking only 60 % of the per capita consumption in the world. With the further development the main problems for Chinese pulp and papermaking industry are:

1) The structure of raw material used is not yet reasonable and the development of the industry is restricted by the shortage of wood supply. Due to the shortage of wood resources, in 2002, wood pulps accounted for only 21 % of all the pulps used for papermaking, furthermore among them only 6 % was domestically produced, which was significantly lower than the world average.

2) The paper and paperboard production could no meet the increasing demand of the country and a large amount of the products have to be imported. In 2002, China imported 5. 27 million tons wood pulp, 6. 87 million tons waste paper, 6. 37 million tons paper and paperboard and 0. 24 million tons paper products, the total cost was more than 7 billion U SD.

3) The scales of the plants are small; the average scales of wood pulping and papermaking plants are 60 kt and 12 kt respectively, while in the world (not including China) the average scales are 180 kt and 80 kt respectively. At present in China there are more than 3 500 pulp and papermaking plants, among them 47 plants have the annual production capacity of more than 100 kt and only 8 plants of more than 300 kt.

4) Compared with developed countries, the overall technological level of the enterprises is still low, especially for the small ones. The total technological and equipment level still rests on the level of developed countries in seventies of the 20th century.

5) Pollutants discharged by this industry, especially high-density organic wastewater, into the aquatic environment, have caused serious environmental degradation. Only a few of the large and medium-sized papermaking enterprises can meet the standards for discharged wastewater. In 2001, the paper and paperboard industry discharged the wastewater in amount of 3. 1 billion tons, accounted 15. 4 % of the total discharged industrial wastewater of the country.

In connection with the above-mentioned problems, recently the State Development and Reform Commission (SDRC) formulated a document^[3]“The National Special Plan of the Forest-Paper Integration Project Construction in Tenth Five-Year and 2010”. According to the plan, in 2005, the consumption of paper and paperboard in China will reach 50 million tons and the wood pulp needed will be 25 % of the total pulps, of which 10 % is considered as domestic production and accounts for 3.8 million tons. It means that 1.8 million tons more wood pulp is necessary to be produced in next year. In 2010, the consumption of paper and paperboard in China will reach 70 million tons and wood pulp needed will be 32 % of the total pulps, of which 15 % is considered as domestic production and accounts for 7.5 million tons, or 3.7 million tons will be increased on the basis of the output in 2005.

Furthermore, in the Tenth Five Year Plan period wood pulp production capacity will be increased in 2.8 million tons (including 0.7 million tons bamboo pulp), and in Eleventh Five-Year Plan period 5.55 million tons of wood pulp production capacity (including 1.2 million tons bamboo pulp) will be further increased.

To achieve the targets, the government will take the following measures:

1) To enhance the construction of forest plantation bases for paper-use. In Tenth Five-Year Plan and Eleventh Five-Year Plan periods, 2 and 3 million hectares forest plantation bases will be established respectively.

2) To build new wood pulping and papermaking plants. In southeast China, 3-4 chemical pulping plants with capacity of 500 000 or more tons pulps, using fast-growing wood as raw material, such as eucalyptus, acacia, pine and others will be constructed. In Yellow River and Huai River areas, several chem-mechanical pulping plants with capacity of 100 000 or more tons pulp will be constructed, using popular as raw material. In the middle and downstream areas of the Yangtze River, mainly the high quality paper and paperboard production, using commercial wood pulp and wastepaper as raw material will be developed. In Southwest area, several bamboo pulping plants will be constructed and in northeast area mainly the forest commercial plantation bases will be established for supplying the wood raw material to the present plants.

3) Continuously to close down small straw pulping and papermaking plants with annual capacity less than 17 kt.

4) To formulate a series of policy to encourage investment, both in China and from abroad, for forest plantation base and pulping plant construction.

5) To enhance the development of national equipment manufacture for the pulp and paper industry.

Based on the above-mentioned measures, we may predict that the forest-paper integration policy will promote the wood pulp and papermaking industry to be quickly developed in China and to be the most important industry in chemical utilization of forest resources. With the development of the wood pulping production, the related chemical processing of tall oil products will also be considered in due course.

2 Naval stores

Gum rosin, turpentine and their processed products are the most important chemical products from non-wood forest resources in China^[4]. Naval stores industry in China is more than fifty years old. In 1936, rosin output was 16 kt; today the production capacity for rosin in China is 700 kt per year. In 2003, the output of gum rosin and turpentine was about 580 kt and 90 kt, respectively. This makes China the largest producer of gum rosin in the world. Gum rosin products are also very important export products for China. The export of gum rosin products in 2003 amounted to about 300 kt, of which about 15 % were reprocessed products. Amongst the 400-500 kt/a trading quantity of rosin in the world, the Chinese gum rosin accounts to about 70 %.

Pine forests are widely distributed throughout China. About twenty species are used for oleoresin tapping, the main ones are: *Pinus massoniana*, *P. yunnanensis*, *P. latteri*, *P. tabulaeformis* and *P. elliotii*. The major oleoresin production areas are located in the southern part of China, namely Guangdong, Guangxi, Yunnan, Fujian, Jiangxi, Hunan and Sichuan Provinces. The rich resources provide favorable conditions for development of the rosin industry.

At present there are more than 400 oleoresin processing enterprises in China and most of them are in small scale and produce only rosin and turpentine. The plants with annual production capacity of more than 10 000 t rosins and having the ability to process rosin derivatives are less than 10 %. The main reprocessed oleoresin products are: hydrogenated rosin, disproportionated rosin, maleated rosin, polymerized rosin, rosin acid salts, rosin resins, synthetic camphor, borneol, terpineol, pine oil, polyterpene resins, α -pinene, β -pinene, linalool and so on. The further development of Chinese oleoresin industry will be concentrated on the following aspects:

- 1) To develop new rosin derivatives with new properties and application areas.
- 2) To expand the application areas of present reprocessed rosin products.
- 3) To increase the export of the reprocessed rosin products accompanied by decreasing the export of raw rosins.
- 4) To introduce and innovate the production technology to raise the product quality and reduce the production cost.

3 Wood-based active carbon

Active carbon is a multi-porous absorbent material, used widely in pharmaceutical, food, sugar and chemical industry as well as for environmental protection. Depending on the raw materials used for production, active carbon may be grouped into coal-based active carbon and wood-based active carbon. The total annual output of active carbon in China is more than 100 kt and ranks the second in the world. Active carbon is one of the main export products in chemical industry of our country. In this paper only wood-based active carbon is discussed.

Wood-based carbon is produced by thermal pyrolysis of woody materials, using both physical and chemical methods. The raw materials used are sawdust, coconut and walnut hulls, various forest and agricultural residues. According to the statistics of State Forest Administration, the output of wood-based active carbon in 2002 was 56 514 t^[5]. Active carbons produced in China, mainly are classified by their usage, for example, pharmaceutical use, sugar use, water purification, carrier use, air purification, gold refining use, etc. In recent years, a series of new products for special uses have been developed to meet the demands of market. The further development of Chinese active carbon industry will be concentrated on following directions^[6]:

- 1) To establish modern active carbon enterprises with advanced technology and equipment. At present there are about 400 active carbon manufacturers in China, most of them are in small scale. With the development and reform of Chinese economy, a series of plants with annual production capacity more than 5 kt have been established which would play important role in production and development of the industry.
- 2) To develop new kinds of active carbon products. At present the variety of active carbon products in China is still not sufficient in comparison with that in developed countries. The further development of new products, such as active carbon with high absorbent performance and high specific surface area, active carbon filter, active carbon fiber, superfine powdered active carbon, active carbon cloth, active carbon electrode and so on are in process.
- 3) To expand the application of active carbons in various industrial areas, especially for water-treatment, environmental protection, catalyst carrier, sugar refining, etc.

4 Tree extractives utilization

4.1 Vegetable tannins

Vegetable tannins are a traditional product of forest chemical products in China. The commercialized products of vegetable tannins in China are tannin extracts, tannic acid and gallic acid as well as their deep-processing products.

4.1.1 Tannin extracts Tannin extracts used for leather industry have previously been one of the important non-wood forest chemical products in China with output reaching more than 50 kt in 1987. Since then, market demand has decreased and output has correspondingly declined. According to the statistics of State Forest Administration the output of tannin extracts was 9 583 t in 2002. The raw materials used mainly are barks of *Larix gmelini*, *Acacia mearnsii* and *Myrica esculenta*. Some high quality tannin extracts in amount of 1-2 kt are imported annually. Various new applications of tannin extracts are under study.

4.1.2 Chinese gallnut Chinese gallnut is a traditional forest special product, which is widely distributed in the mountainous and hilly areas of middle-southern China and is rich in gallotannins. The tannin content of horngall is 62 % - 65 % and 68 % - 72 % for bellygall. Chemically, gallotannins are multiple esters of *D*-glucose with gallic acids. The gallnut is used directly as traditional Chinese medicine and industrially it is used for production of tannic acid and gallic acid as well as their derivatives. The annual output of Chinese gallnut in 2002 was 8 344 t and it was 13 241 t in 1998^[7], the highest in past years. Tannic acid and gallic acid are the main products of the chemical processing of gallnut. More than ten processing plants have been built for the production of tannic acid and gallic acid with an annual output of 2-3 kt. Tannic acid is used as a raw material for pharmaceutical production, ink-making industry, and enrichment of germanium, metal anti-corrosive and as drilling mud treatment agents. Specially treated tannic acid can be used in beer industry as a clarifying agent. Gallic acid is produced by acid or alkaline hydrolysis of tannic acid or of gallnut directly. It can also be hydrolyzed by a special enzyme. Gallic acid is used for preparation of various fine chemicals, such as trimethoxy benzaldehyde, pyrogallol, ellagic acid and other pharmaceutical intermediate products.

4.2 Forest perfume products

The production of forest perfume products in China has a long history and plays an important role in Chinese natural perfume industry. More than 100 plant species are used for production of essential oils and total output amounts to 15-20 kt/a. About 40 % of these essential oils come from forest resources. The main products are eucalyptus oil, *Eucalyptus citriodora* oil, cinnamon oil, star anise oil, cedarwood oil, *Litsea cubeba* oil, camphor oil, etc. Part of the forest essential oils are exported, in 2003 the main exported oils were: eucalyptus oil 3 200 t, star anise oil 630 t, *Litsea cubeba* oil 300 t, camphor oil 300 t and cinnamon oil 400 t.

Beside the direct use of essential oils, they are also used for further processing to separate some special compositions, used in medicine and fine chemicals production, such as cineol from eucalypt oil, citral from litsea oil, cedrol and cedrene from cedarwood oil, anethole from star anise oil, cinnamaldehyde from cinnamon oil.

4.3 Forest medicinal and health products

China is well known for its long history and the associated accumulated knowledge of the medicinal use of plants, which forms Chinese traditional medicine. Numerous Chinese herbs have been recorded in pharmacopoeias and medicinal books. In this paper, only the medicinal and health products extracted and purified from forest plants are discussed. With the development of phytochemistry and advanced analytical techniques, the study of the effective components of medicinal plants has made a great contribution to the

pharmaceutical industry to produce many new medicines for the treatment of various diseases.

At present various tree extracts, used as raw medicine in pharmaceutical industry, are produced. The most important ones are *Ginkgo biloba* extract, *Eucommia ulmoides* extract, *Magnolia officinalis* extract, rutin from *Sophora japonica*, saponins from *Aralia chinensis* and *Gynostemma pentaphyllum*, *Acanthopanax senticosus* extract, proanthocyanidins from pine bark, camptothecine from *Camptotheca acuminata*, harringtonine from *Cephalotaxus fortunei*, taxol from *Taxus chinensis*, natural bornol and camphor, sea buckthorn oil and extracts, etc.

5 Conclusion

Chemical utilization of forest products is one of the important fields of effective and sustainable utilization of forest resources. At present the development of forest chemical industry is facing new opportunities and challenges. For the wood chemical utilization, wood pulping and papermaking industry has a great demand on market and will be rapidly developed, but its development is limited by the shortage of wood supply in China. The forest-papermaking integration policy will provide a good opportunity for the development of wood pulping industry. The production of wood-based active carbon will meet the challenge from coal-based active carbon production. Further efforts must be taken to develop new special variety of products on the advantages of wood-based materials to keep on its continuous development. For chemical utilizations of non-wood forest products, the production of forest chemicals, including oleoresin, vegetable tannins, essential oils and their deep-processing chemical products, is facing the challenge from the petroleum and other chemical products. Only thorough enhancing the continuous innovation of the knowledge and technology, improving the technology and developing new value-added products, the production of forest chemicals may take its own position and be developed further.

China is a vast country with a wide variety of climatic environments as well as plant species. It provides a great space and favorable conditions for development of various forest chemical products. The raw materials used for forest chemical industry are renewable resources and mainly come from forest and mountain areas. The development of forest chemical products on the basis of advanced technology, rational management and protection of the natural resources is significant for development of the local economy and benefit to the local people.

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