Development of Elemental Technology and Creation of New Industry toward Social Implementation of Sustainable Natural Rubber Ecosystem

Toward achieving the Sustainable Development Goals (SDGs), attempts were made to establish a base of innovative technologies to create new industries with natural rubber as one of the sustainable biological resources: that is, development of new technologies to dry natural rubber latex for mass production of protein-free natural rubber, to vulcanize protein-free natural rubber, to biodegrade natural rubber products and to conserve environment through resource recovery type wastewater treatment. In 2020, some parts were prepared for spray drum dryer that shorten the drying time of natural rubber from 2 hours to less than a minute and vulcanization of natural rubber was performed after mixing vulcanizing agents using a spray drum dryer. The biodegradation of natural rubber was performed with natural rubber degrading bacteria in flask and a white-rot-fungus that produce devulcanizing enzyme was found for recycling of waste of natural rubber products. Equipment for laboratory experiments was installed to develop a technology for removing organic substances from natural rubber wastewater containing high concentration of ammonia and recovering methane. Continuous wastewater treatment was carried out with an electron-conductive material that promotes electron transfer between microorganisms. Wastewater treatment system of natural rubber manufacturing plant in Vietnam was surveyed in collaboration with Vietnamese universities and basic information were collected to assess quality of treatment water and its processing costs.

Development of technology to dry natural rubber latex for mass production of protein-free natural rubber

It is necessary to develop new technology to dry natural rubber from the latex, since the rubber is damaged by current drying process performed at 130 ºC for 2 hours. Thus, we designed a spray drum dryer (SDD) with IH heater (Figure 1) to dry the rubber for less than a minute and prepared some parts, as shown in Figure 2. In addition, a heating device as a model for SDD was installed at Nagaoka University of Technology, National Institute of Technology, Tokyo and Numazu College, and Hanoi University of Technology. Natural rubber latex and deproteinized natural rubber latex were dried at 150 ºC for 45 seconds to a water content of 1 % or less without oxidation and degradation.

Fig.1 IH heater.

Fig.2 Base of SDD.

Development of technology to vulcanize protein-free natural rubber

Vulcanization of natural rubber with the SDD was investigated to develop a new vulcanization procedure for protein-free natural rubber. Natural rubber was mixed with sulfur, ZnO and stearic acid in latex stage and it was dried with the heating device as a model SDD followed by vulcanization at 150 ºC for a suitable vulcanization time determined by NMR spectroscopy (Figure 3). The mechanical properties of the resulting vulcanized natural rubber were found to be superior to those of the

Fig. 3 NMR measurement.

conventional vulcanized natural rubber. In addition, natural rubber latex containing sulfur, ZnO and stearic acid was dried using a demo machine for the SDD to prepare an as-cast film as a natural rubber compound.

Development of technology to biodegrade natural rubber products and preparation of international standard

Biodegradation of natural rubber was successfully performed with natural rubber degrading bacteria in flask (Nagaoka University of Technology). In addition, a white-rot-fungus that produce devulcanizing enzymes was found for recycling of waste of natural rubber products (Tottori University of Environmental Studies). These achievements make possible to develop an innovative biodegradation technology as a base. By contrast, biodegradation conditions were investigated with a tensile test instrument (Figure 4) to evaluate degree of biodegradation system and BOD (biochemical oxygen demand) sensor to establish an international standard for natural rubber biodegradation.

Fig. 4 Tensile test instrument.

Development of technology to conserve the environment through resource-recovery-type wastewater treatment

In an attempt to develop advanced resource-recovery-type wastewater treatment technology combined with an ABR reactor and DHS reactor, it is possible to remove organic substances and nitrogen sources, recover methane at a high level, and suppress greenhouse gas emissions. Equipment for laboratory experiments (Figure 5) was installed to develop a technology for removing organic substances from natural rubber wastewater containing high concentration of ammonia and recovering methane. Continuous wastewater treatment was carried out with an electron-conductive material that promotes electron transfer between microorganisms. Wastewater treatment system of natural rubber manufacturing plants in Vietnam was surveyed in collaboration with Vietnamese universities, and basic information was collected to assess the quality of treated water and its processing costs. We found that natural rubber wastewater was treated with industrial wastewater discharged from various factories by an industrial wastewater treatment system installed in an industrial park (Figure 6).

Fig.5 Equipment for laboratory experiments.

Fig. 6 Industrial wastewater treatment system.