Rubber Science and Technology for the Twenty-First Century

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Abstract

What is a rubber science strategy that centers on low carbon technology? Is it development of natural rubber (NR), innovation of cross-linking, and/or progress of reinforcing filler? We can find various subjects from a viewpoint of sustainability science. Most of the themes presented in this conference are supposed to be related to the rubber science strategy. In our research group, several studies have been also conducted for the sustainability rubber science. Because of the biosecurity and biodiversity problems of *Hevea* NR, for examples, the studies on guayule and rubber dandelion NRs have been started in order to investigate their strain-induced crystallization (SIC) behaviors by using quick *in situ* simultaneous synchrotron time-resolved wide-angle X-ray diffraction/tensile measurements at SPring-8 [1,2]. It was found that both guayule and rubber dandelion NRs showed comparable SIC behaviors similarly with *Hevea* NR, and are useful as alternatives of *Hevea* NR. In terms of sustainable development and carbon-neutral products, biofillers such as cellulose nanofibres, biosilica, and lignin have attracted the attention of many researchers. Among them, lignin is the second most abundant biopolymer after cellulose. The effective use of lignin waste from kraft processes is gaining focus. By using the soft processing method, high performance eco-friendly NR biocomposites filled with lignin were successfully prepared from sodium lignosulfonate and NR latex [3,4]. Formation of a network-like lignin structure was achieved around the rubber phases, which resulted in a superior reinforcement effect of lignin for NR. This observation will open a window for lignin to be used as a reinforcing filler in rubber industry. Furthermore, the most important cross-linking reaction in rubber industry i.e. vulcanization has been focused in order to reveal its reaction mechanism which controls network structures in vulcanizates [5,6,7]. The dinuclear type bridging bidentate zinc/stearate complex composed of $(Zn_2(\mu\text{-}O_2CC_{17}H_{35})_2)^{2+}\cdot 4X$ (the zinc/stearate complexes with the ratio of 2/2) was revealed as an important intermediate to start the vulcanization in the presence of zinc oxide and stearic acid. In the long history of the vulcanization technique until 2015 starting from the innovation by Goodyear, followed by the sophisticated vulcanization technique established in the 1960s or 1970s, the newly observed intermediate may bring about a turning point for the second paradigm of vulcanization technique in the 21st century. Let's start to discuss important roles of rubbers and elastomers for this century.

Fig.1 Rubber dandelion.

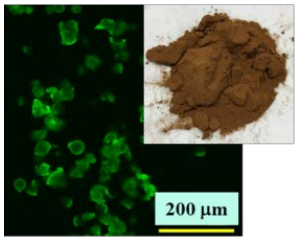

Fig. 2 Lignin powder.

References

(1) Y. Ikeda, P. Junkong, T. Ohashi, T. Phakkeeree, Y. Sakaki, A. Tohsan, S. Kohjiya and K. Cornish. *RSC Adv*. **2016**, *6*, 95601.
(2) P. Junkong, T. Ohashi, T. Phakkeeree, Y. Sakaki, A. Tohsan, K. Cornish, and Y. Ikeda. *Kautsch. Gummi Kunstst.* (Impress).
(3) T. Phakkeeree, Y. Ikeda, H. Yokohama, P. Phinyocheep, R. Kitano and A. Kato, *J. Soc. Fiber Sci. Technol.* **2016**, *72*, 160.
(4) Y. Ikeda, T. Phakkeeree, P. Junkong, H. Yokohama, P. Phinyocheep, R. Kitano and A. Kato. *RSC Adv*. **2017**, *7*, 5222.
(5) Y. Ikeda, N. Higashitami, K. Hijikata, Y. Kokubo, Y. Morita, M. Shibayama, N. Osaka, T. Sizuki, H. Endo and S. Kohjiya. *Macromolecules*. **2009**, 42, 2741.
(6) Y. Yasuda, S. Minoda, T. Ohashi, H. Yokohama and Y. Ikeda. *Macromol. Chem. Phy.* **2014**, *215*, 971.
(7) Y. Ikeda, Y. Yasuda, T. Ohashi, H. Yokohama, S. Minoda, H. Kobayashi and T. Honma, *Macromolecules*, **2015**, *48*, 462.

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