Mechanochemical Synthesis of poly(lactic acid)

Jeung Gon Kim[1], Nuri Ohn[2]
[1]*Department of Chemistry*
Chonbuk National Univerisity
567 Baekje-daero, deokjin-gu, Jeonju-si,
Jeollabuk-do 54896 Republic of Korea

*E-mail: jeunggonkim@jbnu.ac.kr

Mechanical force driven synthesis has drawn an intense attention as a powerful alternative to conventional chemical synthesis.[1-3] Its way of conveying energy to promote chemical transformations is completely different from photo-, electro-, or thermal activations. The collision impact between hard substances delivers energy and mixing to chemical mixtures, where chemical transformation happens. The usefulness of mechanochemical synthesis, mostly ball milling techniques, has been proven in many organic reactions, for instance, imine formation, palladium catalyzed couplings, the Witting reactions, metal mediated C-H couplings, and metal-organic framework formations. Additional important merit of solid state chemical transformation is 'solvent free synthesis'. In terms of green chemical aspects, use of no solvent would reduce a significant portion of chemical wastes. Also the maximization of effective chemical concentration could be beneficial for a reaction rate enhancement.

Despite of those very attractive features, its application to polymer synthesis is currently in premature status. Only the synthesis of poly(phenylene vinylenes) and Poly(aryl imines) was investigated so far. [4-6]

Given the interesting reactivity and appealing green chemical merits, we began the study on bio-based polymer synthesis, presenting herein poly(lactic acid).[7]

PLA is not only renewable but also has many good mechanical properties, thus being currently utilized in many applications. Many catalysts have been reported for lactide polymerization in solution. We will present our results on various catalyst screening and reaction parameter effects using ball-mill technique (Figure 1 and 2). By the face to face comparison between solution and mechanochemical conditions, we would like to provide the better picture of ball-mill chemistry for polymer science.

Fig.1 MM400 Ball-Milling Machine used in this study.

Fig. 2 Ball-Mill Synthesized PLA.

REFERENCES

[1] J.-L. Do and T. Friščić, ACS Cent. Sci., 3 (2017) 13.
[2] J. G. Hernández and C. Bolm, J. Org. Chem., 82(2017) ASAP.
[3] B. Ranu and A. Stolle, Ball Milling Towards Green Synthesis, The Royal Society of Chemistry, Cambridge, 2015.
[4] J.B. Ravnsbæk and T.M. Swager, ACS Macro Lett., 3(2014) 305.
[5] S. Grätz and L. Borchardt, RSC Adv., 6(2016) 64799.
[6] Y. Zhao, S.V. Rocha and T.M. Swager, J. Am. Chem. Soc., 138(2016) 13834.
[7] R. Auras, L.-T. Lim, S.E.M. Selke and H. Tsuji, Poly(Lactic Acid): Synthesis, Structure, Properties, Processing, and Applications, Wiley, Hoboken, 2010.