Highly Reactive Polybutenes and Polyisobutylenes

Polybutenes and polyisobutylenes (PIBs) of low molecular weight are valuable lubricants and viscosity modifiers.[1] Polybutenes and PIBs with high levels of terminal olefinic groups are of great utility as they readily undergo chemical reactions to form specialty lubricant additives and thus are termed *highly reactive*. Two prime examples (Figure 1) of important liburicant additives made by post-polymerization functionalization of highly reactive PIBs are polyisobutenylsuccinic anhydrides (**1**, PIBSAs) and polyisobutenylsuccinimides (**2**, PIBSIs).[1e]

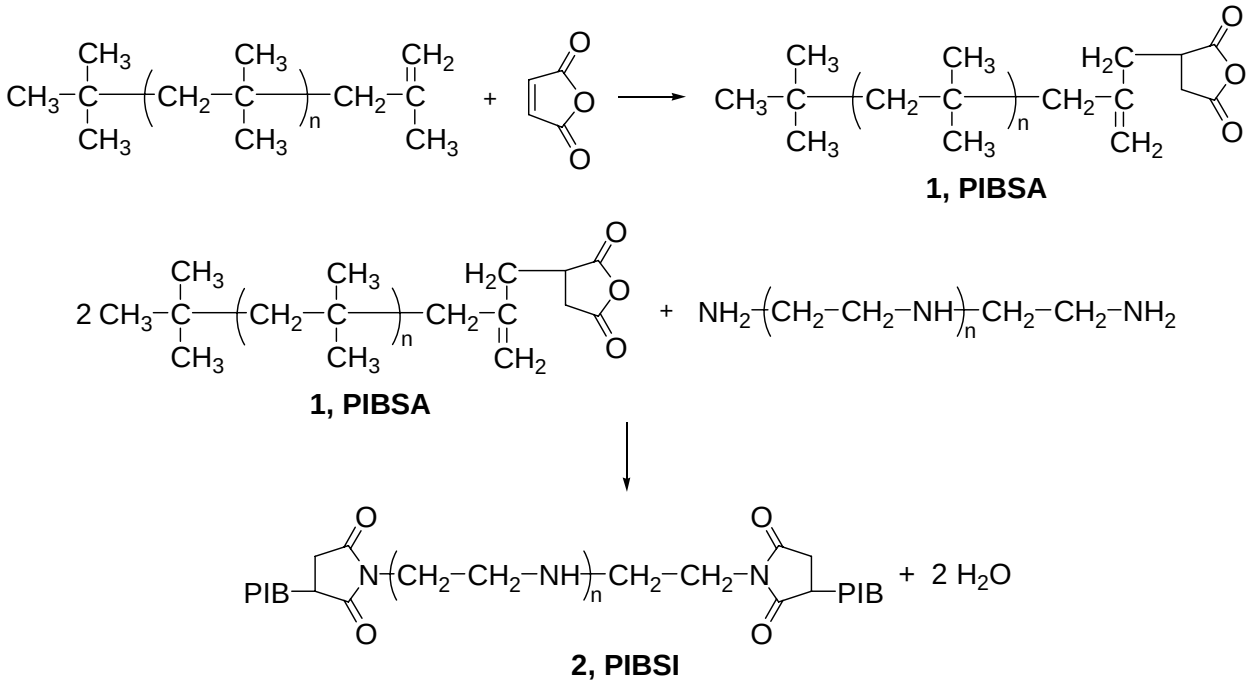

Figure 1. Synthesis of PIBSA and PIBSI from Highly Reactive PIB.

PIBSAs are used as corrosion inhibitors whereas PIBSIs are useful in preventing sludge formation. The corresponding polybutenylsuccinic anhydrides (PBSAs) and polybutenylsuccinimides (PBSIs) have identical uses and are manufactured in a similar manner with the exception that highly reactive polybutenes are used in place of highly reactive PIBs.

Market Overview

Polybutenes are ill-defined copolymers of isobutylene and minor amounts of 1-butene and Z/E 2-butenes.[1c,e] They materials with low number average molecular weights ($\overline{M_n}$ = 340-2200 g mol^{-1}) with viscosities ranging from 20 centistokes (cSt) to 7x10^4 cSt and their primary application is as lubricants and viscosity modifiers.[1c,e] More than 750,000 metric tons of polybutenes are produced each year at an average cost of \$1 kg^{-1}.[1e] Production of high molecular weight polybutenes requires low temperatures and is costly. Polybutenes with high levels of terminal unsaturation are valuable in the production of lubrication additives but no cost effective and environmentally acceptable system exists for their production.[1c&e,2] Exxon, Amoco, BP, and BASF are major manufacturers of polybutenes.

Polyisobutylene (Figure 2) is a well-defined homopolymer of isobutylene. Depending on

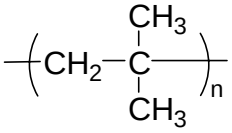

Figure 2

$\overline{M_n}$ the physical properties can range from liquids to semiliquids and solids. End uses include lubricants, sealants, and adhesives. A process referred to as *chain transfer* limits ultimate polymer molecular weights and can be suppressed by reducing the polymerization temperature.[3] Since $\overline{M_n}$ is inversely proportional to the polymerization temperature the manufacture of high $\overline{M_n}$ PIBs is costly. Traditional methods[4] for the preparation of high molecular weight PIBs (> 10^5 g mol^{-1}) require polymerization temperatures ≤ -100 °C in order to reduce chain transfer to an acceptable level. In some cases (processes using $AlCl_3$)[1] toxic solvents (*e.g.* methyl chloride) are required for polymerization; strict regulations prohibit the building of new or expansion of existing plants that require such materials. BASF is the largest manufacturer of PIBs (10^6 metric tons $year^{-1}$ with costs ranging \$0.8 kg^{-1} for low $\overline{M_n}$ grades and \$1.7-2 kg^{-1} for medium to high $\overline{M_n}$ grades).[5] PIBs bearing a high (> 80 %) percentage of terminal unsaturation (reactive PIBs) are highly desirable but a cost effective, non-polluting system for their production has not been disclosed.[2]

Our Novel and Commercially Viable Technology

Innovative Science, Inc. has catalogued a number of potential methodologies for the production of highly reactive polybutenes and PIBs with > 80 % terminal olefinic groups in a cost effective and environmentally friendly manner. Each perspective process relies on the use of a drop-in catalyst that is fully compatible with equipment currently being used to manufacture these products. Each catalyst is of moderate to low cost and is capable of operating in the absence of harmful solvents.

Cost = \$20,000-25,000 initial testing and patenting.
Likelihood of success = 65%
Earning potential = 8.25
Return on investment = The investor will receive 50 % of both the intellectual property rights and profits stemming from this research effort.

References

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2. (a) Rath, H. P.; Hahn, D.; Sandrock, G.; Deyck, F.; Straeten, B. V.; Vree, E. D. US Patent 6,753,389 (2004). (b) Nolan, J. T., Jr.; Chafetz, H. US Patent 3,024,226 (1962). (c) Nolan, J.

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3. (a) Kennedy, J. P. *Carbocationic Polymerization of Olefins*: *A Critical Inventory*; Wiley: New York, 1975; Ch 4. (b) Innovative Science, Inc. has developed a technology that makes use of other techniques besides reduced reaction temperature to reduce the extent of chain transfer.
4. Otto, M.; Müller-Cunradi, M. Ger. Patent 641,284 (1931).
5. Marsalko, T. (BASF) *personal communication*, **2005**.