Synthesis of Hydroxyl Terminated Epoxidized Natural Rubber as a Binder for Solid Rocket Propellant

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Introduction

- Low molecular weight rubber which identified as liquid natural rubber (LNR) is another option to transform rubber into functional products.
- LNR is more preferred and has attracted industrial attention particularly to ease rubber processing and acting as reactive plasticizer in tyre industry.
- In contrast to LNR, only a few studies reported on liquid epoxidized natural rubber (LENR).
- The presences of epoxy groups in epoxidized natural rubber (ENR) provide an opportunity to extend its reaction.
- In fact, ENR has improved oil resistance, reduce gas permeability and altering damping amount in contrast to NR.

- Currently, in solid rocket propellant application, the most widely use rubber binder is HTPB due to high mechanical properties at low temperature and ballistic performance.

- Unlike ENR, HTPB is produced by synthetic rubber which is depending on petroleum based industry. Therefore it is worth it to find another alternative to substitute HTPB that possess similar properties as well as to promote green technology.

- Thus this work aimed to study the effect of reaction time and cobalt amount on molecular weight of HTENR that suitable to be utilized as a binder for solid rocket propellant application. Burning rate test was carried out to evaluate the performance of solid rocket propellant.

Methodology

Synthesis of hydroxyl terminated epoxidized natural rubber

GPC characterization

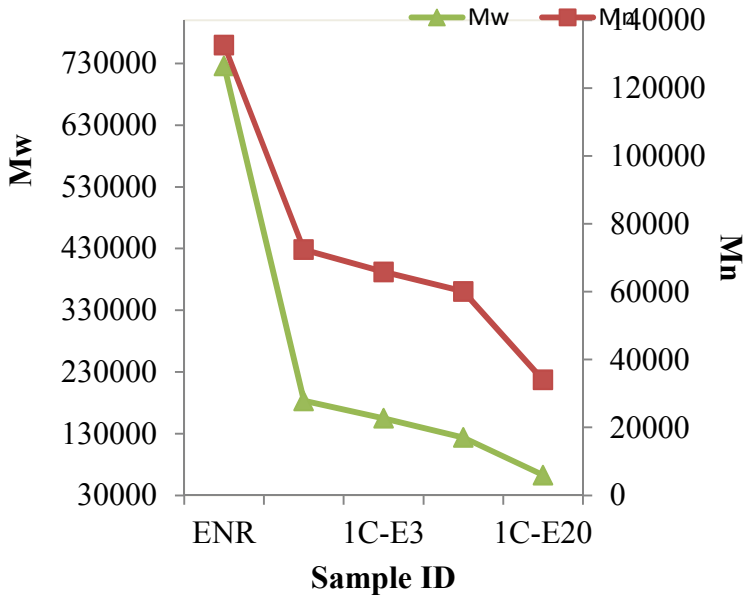
Preparation of solid rocket propellant

Burning rate test

Results & Discussion

Effect of Reaction Time on Mn and Mw of ENR and LENR

- Mn and Mw of HTENR were decreased with increasing the reaction time.
- The Mn of the original ENR with a polydispersity of 5.5 was quickly cut off almost into half for the first 1 hours of synthesis process and slowly decreased afterwards.
- The polydispersity index approaches 2 which indicated narrow molecular weight distribution.
- These results were in agreement to the increased in number of chain scission in polymer molecule along the process with increasing reaction time.

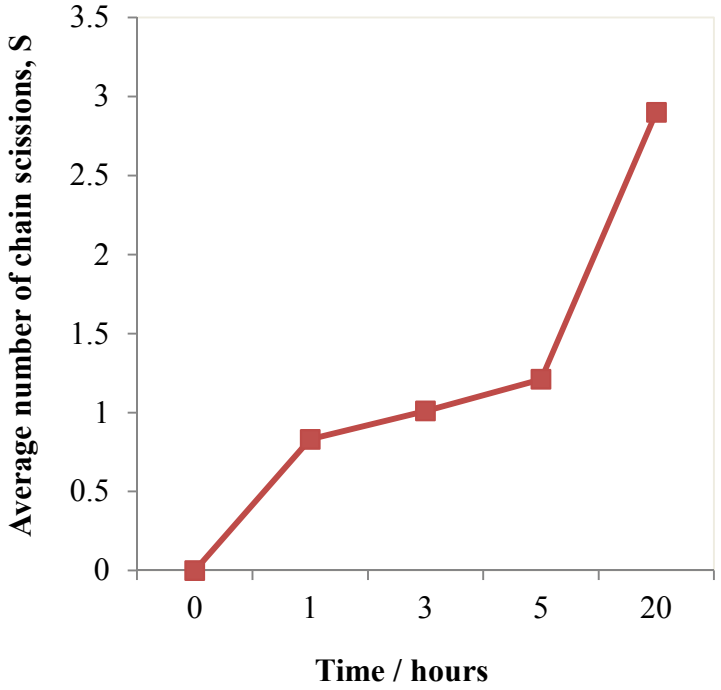


Number of Chain Scission of LENR

$$S = \frac{\overline{(Mn)_0}}{\overline{Mn}} - 1$$

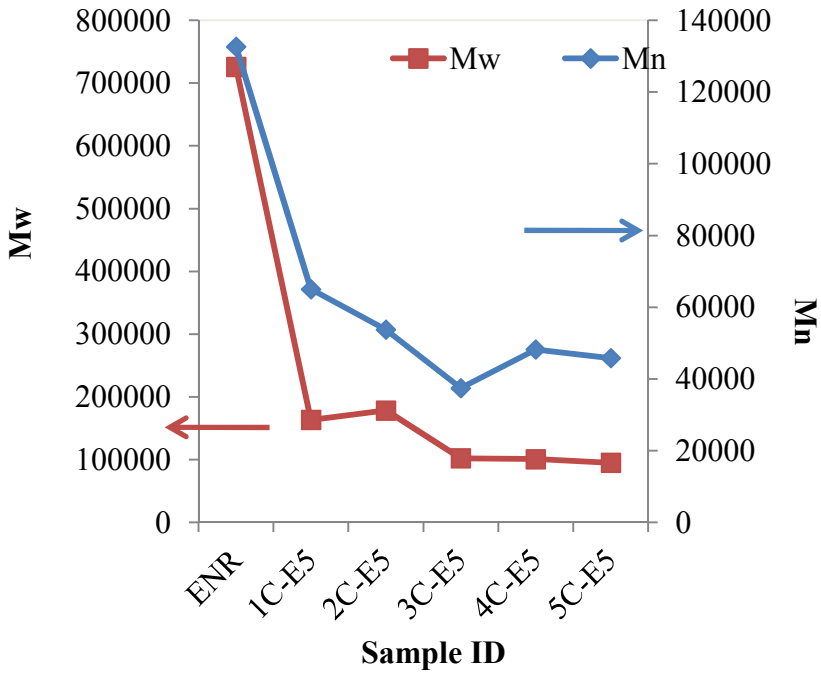
S ; The average number of chain scissions
$(Mn)_o$;the number average molecular weights before degradation
Mn ;the number average molecular weights after degradation

- S increases rapidly for the first one hour and slowly increasing subsequently.
- About 74% from original molecular weight was reduced after twenty hours reaction.
- As a result, higher reaction time is favor to achieved lowest Mn.
- However, for industrial production, longest reaction time seems not applicable and consumes larger energy and cost.
- Therefore reaction of five hour is chosen for larger scale production.



Effect of Cobalt Percentage on Mn and Mw of ENR and LENR

- Increasing the amount of cobalt from 1% to 5% at constant reaction time caused in reduction of Mn and Mw.
- Same trend were observed for both series.
- However higher reduction in molecular weight was observed by varying the cobalt amount rather than varying the reaction time.
- These results were significant with the properties of cobalt to enhance chain scission during depolymerization process.



Burning rate of HTENR and HTPB based binder

Sample	Burning rate (mm/s)
HTENR	2.93
HTPB	3.00

- Table shows the result of burning rate test for HTENR and HTPB based binder in open atmosphere.
- Both sample produced almost similar result which are 2.90mm/s and 3.00mm/s.
- Therefore, HTENR binder is suitable to be used in solid rocket propellant. However different data range of burning rate explained appropriateness to be used in different application.
- As a result, it is important to know the burning rate of solid propellant before decide in which field of application is the binder fit to be used.

Summary

- HTENR was synthesized via depolymerization of ENR using chain scission agent in solvent.
- Lower molecular weight of HTENR was obtained at three percent of cobalt after five hour reaction at 60^{o}C.
- Burning rate test at open atmosphere shows that HTENR and HTPB binder produced almost similar result which mentioned that HTENR is suitable to be used as a binder for solid rocket propellant application.
- However, further investigation on HTENR properties is required for future development in aerospace area.

THANK YOU