

고체 추진제의 새로운 경화시스템에 관한 연구

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A Study on New Curing System Available for Solid Propellant

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ABSTRACT

In this study, Instead of using urethane curative systems, which have long been used as solid propellants, a triazole curative system has been introduced into a new binder recipe in which azide groups in the polymer react with triple bonds of a dipolarophile curative.

초 록

본 연구에서는 고체 추진제에서 널리 사용되어 왔던 우레탄 경화시스템 대신 아지드 고분자와 친양극성체를 이용한 트리아졸 경화시스템에 관한 바인더 연구를 수행하였다.

Key Words: Triazole-linkage(트리아졸 연결), Urethane-linkage(우레탄 연결), Azide polymer(아지드)

1. 서 론

The urethane curing system has a few shortcomings that need to be resolved. Primarily, the curing system, which is sensitive to moisture, has required the strong action that eliminates moisture present both in ingredients of propellant and in atmosphere surrounding manufacturing. For these reasons, a new curing system available for solid propellants as a replacement for urethane

curing systems has been consistently demanded.

Since the late 1980s, triazole curing systems have slowly become of interest, however, with few published results, including a few patents and a few papers published recently [3-5]. Triazole crosslinked networks are readily formed by the 1,3-dipolar (3+2) cycloaddition between azidomethyl groups in a polyether-type polymer backbone and the triple bonds of a di- and/or tri-acetylene compound (multifunctional dipolarophile curative)

In this study, we used commercially

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available GAP as a prepolymer to form a triazole cured network by the cycloaddition with dipolarophile curatives.

2. Experimental

The polymers used in this study were hydroxyl-bi and trifunctionalized GAPs (Bi-GAP and Tri-GAP) with molecular weights and hydroxyl indexes of 2,400 g/mol, 0.74 eq/kg, and 5,500 g/mol, 0.49 eq/kg, respectively, and were purchased from 3M under the trade names GAP diol (L9961) and GAP polyol(5527). IPDI, with a molecular weight/isocyanate index of $222 \text{ g} \cdot \text{mol}^{-1}/8.86 \text{ eq} \cdot \text{kg}^{-1}$, was purchased from Mobay. BPS(aliphatic diacetylene-type) and BEHB(aromatic diacetylene-type) were used as a dipolarophile agent.

3. Result and discussion

3.1 Preparation of triazole crosslinked network

Unlike the polyurethane system crosslinked by the equivalent reaction between hydroxyl groups in the polymer and isocyanate groups in the curative, triazole linkage among azide polymer chains should be formed by modulating the amount of dipolarophile featuring alkynes based on the amount of azide polymer.

3.2 Mechanical properties

Mechanical properties of triazole crosslinked networks prepared using Tri-GAP, a mixture of Tri-GAP and Bi-GAP, and Bi-GAP were shown in Table 1.

As expected, by increasing the content of curatives, the strength of the networks was increased and the flexibility of networks was diminished. Although the crosslink densities of networks with BHPB were higher than that of

networks with BPS, the stress of the former was not always higher than that of the latter and in some cases the stress of the latter was even slightly higher than that of the former (No. 2 and No. 5). Moreover, it was found that there was no distinguishable difference between BHPB and BPS in the field of strain. However, if the polymer chains were crosslinked very loosely (No. 4 and No. 8), the stress of the networks crosslinked with BPS was higher than that of the network crosslinked with BHPB.

Table 2. Mechanical characteristics of triazole crosslinked networks based on GAP and dipolarophile Curatives

No.	Polymer	Amount of dipolarophile curative (pph)	Mechanical properties (BEHB : BPS)		
			Max. stress kPa	Max. strain %	Hardness
1		5	210 : 150	74 : 85	14 : 10
2	Tri- GAP	7	360 : 420	43 : 47	31 : 35
3		10	790 : 690	42 : 34	47 : 47
4	Tri-and Bi-	5	100 : 80	106 : 178	3 : 0
5	GAP(wt.	7	260 : 300	81 : 77	17 : 20
6	l/l)	10	650 : 500	53 : 41	44 : 40
7		5	Binder uncured		
8	Bi-GAP	7	70 : 60	133 : 174	0 : 0
9		10	340 : 340	74 : 61	24 : 24

4. Conclusion

Aliphatic (BPS) and aromatic (BHPB) dipolar curatives were successfully synthesized to prepare the triazole crosslinked networks based on GAP.

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