Influence of Lithium Fluoride on the Burning Rate of AP-Polyester Propellant

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THE addition of catalysts normally serves the purpose of imparting a desired burning rate change in a composite propellant. These may either retard or enhance the burning rate. Some often quoted catalysts are oxides, chromites and chromates of metals. A lot of work has been done on finding the effect of the addition of some of these catalysts on the burning rate; however, none seems to have appeared on the influence of lithium fluoride (LiF). Only qualitative reduction in the burning rate of composite propellants with the addition of LiF was reported by Williams et al.[1] Dickinson and Jackson[2] reported a slight decrease in the specific impulse of composite propellant with the addition of LiF; however, they made no mention of the effect of its addition on the burning rate. We have studied the effect of the addition of varying amounts of LiF on the burning rate of Ammonium Perchlorate (AP)-Polyester propellant.

Experimental Details

Before the influence of LiF concentration on the burning rate could be studied, considerable number of trials were made to find proper composition and mixing, casting and curing schedule to achieve reproducible burning rate results. A brief account of the procedure finally developed and followed for preparation of propellant grains is given below.

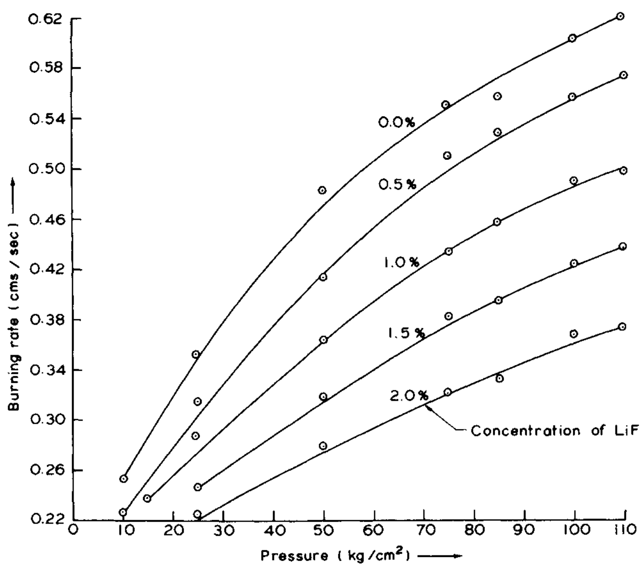

Fig. 1 Burning rates of propellants with various percentages of lithium fluoride.

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Table 1 **Constants and standard deviation obtained for different sets of data**

Concentration of LiF	Summerfield Relation C_1	C_2	σ^a	Power Law Equation a	n	σ^a
0.0	6.15	7.41	0.357	0.1043	0.4017	0.0036
0.5	10.52	7.88	0.711	0.0887	0.3982	0.0047
1.0	12.15	9.03	0.620	0.0781	0.3922	0.0031
1.5	16.47	10.24	0.799	0.0684	0.3827	0.0035
2.0	5.94	12.65	0.819	0.0728	0.3461	0.0038

^{a} σ = standard deviation.

Ammonium Perchlorate (AP) with a bimodal distribution having average particle sizes of 130 and 275 μ was prepared. The liquid resin consisting of polyester, styrene and dioctylphthalate (DOP) was prepared and transferred to a sigma blade mixer. AP was then added in three batches to the resin. Finally the initiator methyl ketone peroxide (MEKP) and the accelerator cobalt naphthanate were mixed. The whole mixing operation was completed in an hour and a half. The mass containing 70% solid loading was transferred into a glass tube wherein casting was done under vacuum. Curing was then done for 18, 6, and 48 hr, respectively, at 25, 60 and 25°C. The cured propellant was cut into 6 in. long strands having a cross section of $\frac{1}{4}$ in. × $\frac{1}{4}$ in. and inhibited on their longer sides using epoxy resin. A uniform mix of LiF was achieved by adding it prior to AP addition. Lithium fluoride concentration was varied from 0.5% to 2.0% in steps of 0.5%.

The burning rates of propellant strands at different pressures were obtained using Crawford Bomb. Nitrogen was used for pressurization and the strands were ignited by means of electric spark. An electric timer capable of measuring one hundredth of a second and operated on relay was employed for measuring the time to burn a known length of strand. From a knowledge of the time and the length of the strand, the burning rate at any pressure was calculated.

Results and Discussion

Figure 1 shows the variation of the burning rate of propellant with pressure for various percentages of LiF concentration. A curve fit for each set of data is made using the Summerfield's relation[3]

$$1/r = C_1/p + C_2/p^{1/3}$$

as well as power law equation, $r = ap^n$. Table 1 presents the constants obtained along with the corresponding standard deviations for each equation and for different sets of data. It is evident that the burning rate data can be better approximated by power law equation than the Summerfield's relation. It may also be seen that pressure exponent continually decreases with increasing amount of LiF. It appears that with an appropriate amount of LiF a near pressure independence of the burning rate may be attained. But in practice, we have found that in the pressure range studied (10–110 kg/cm^2) smooth burning of the strand has become difficult when concentration of LiF has been increased beyond 2%.

References

[1] Williams, F. A., Barrere, M., and Huang, N. C., *Fundamental Aspects of Solid Propellant Rockets,* 1st ed., Technovision Services, Slough, England, 1969, Chap. IV, p. 196.

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[3] Summerfield, M., Sutherland, G. S., Webb, M. J., Tabak, H. J., and Hall, K. P., "Burning Mechanism of Ammonium Perchlorate Propellants," *Progress in Astronautics and Rocketry, Vol. 1. Solid Propellant Rocket Research,* 1st ed., Academic Press, New York, 1960, pp. 141–160.