

ZINC SULFIDE FLAME RETARDANT PERFORMANCE COMPARATIVE ANALYSIS

Zinc sulfide (ZnS) is an important inorganic compound with broad applications in materials science, among which its use as a flame retardant and flame-retardant synergist is particularly notable. Owing to its good thermal stability and excellent optical properties, ZnS is often employed in functional composite materials such as plastics, rubbers, coatings, adhesives, and electronic components. In flame-retardant applications, ZnS primarily functions through the following mechanisms:

- Synergistic flame-retardant effect:** Zinc sulfide can be used in combination with halogen-based flame retardants and others to produce a synergistic flame-retardant effect. This synergistic system not only improves the flame-retardant efficiency of the material under fire conditions but also effectively suppresses the release of toxic smoke and harmful gases during combustion.
- Alternative to antimony trioxide (Sb₂O₃):** In certain polymer systems (such as nylon), ZnS can serve as a partial or complete environmentally friendly substitute for the traditional flame-retardant synergist Sb₂O₃. While maintaining the flame-retardant rating of the material, it helps reduce potential impacts on the ecological environment and human health.
- Enhancing thermal stability of materials:** The addition of ZnS can improve the thermal stability of composite materials, delay the thermal degradation process of the matrix, and thereby indirectly enhance the material's resistance to combustion under high temperatures or fire exposure.

COMPARATIVE FLAME-RETARDANT PERFORMANCE ACROSS PLASTIC TYPES

Plastic Type	Flame Retardant Loading (%)	Flame Retardant					
		100% Sb ₂ O ₃		50% Sb ₂ O ₃ / 50% ZnS		100% ZnS	
		Oxygen Index (%)	UL-94 Rating	Oxygen Index (%)	UL-94 Rating	Oxygen Index (%)	UL-94 Rating
PVC-U	3	46	V0	50.9	V0	46.6	V0
PVC-P	5	26.5	V0	28.2	V0	24	V1
PVC Paste	8	27.5	V0	27.5	V0	22	V2
HDPE*	5	29.5	**	29.5	**	24.5	**
PP*	5	24.5	**	25.5	**	23.5	**
PS*	5	--	**	24.5	**	25	**
PA-6*	5	27	V0	24	V2	25	V1
PET*	5	39	V0	38	V0	32	V0
ABS*	5	26	V0	23	V0	21	**

Test Protocol: ASTM D2863

Remark:

- * 10% brominated diphenyl ethers added as basic Flame Retardant and Sn203 (and other) acting as flame retardant synergist to reduce the use of brominated diphenyl ethers.

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** No information provided by UL-94

RESULTS ANALYSIS AND DISCUSSION

Table 2 presents the Oxygen Index test results and UL-94 flammability ratings for flame retardant systems using solely ZnS, solely Sb₂O₃, or an equal mixture of both, in various plastic matrices.

The results indicate that replacing 50% of Sb₂O₃ with ZnS generally maintains the same UL-94 flame retardancy rating for most plastics, with the exception of PA-6. In PA-6, partial substitution (50% ZnS) leads to a decrease in performance (UL-94 V2), while using 100% ZnS results in better performance (UL-94 V1).

For PVC, PP, and PS, the use of 50% ZnS as a replacement for Sb₂O₃ leads to an increase in the Oxygen Index, suggesting an improved flame retardant effect.

Based on the combined Oxygen Index and UL-94 test results, the feasibility of replacing Sb₂O₃ with ZnS is summarized as follows:

- **PVC-U:** Can be 100% replaced.
- **PVC-P:** Can be 75% replaced.
- **PVC Paste:** Can be 50% replaced.
- **HDPE:** Can be 50% replaced.
- **PP:** Can be 50% replaced.
- **PS:** Can be 100% replaced.
- **PA-6:** Partial replacement is not recommended; complete replacement can be considered.
- **PET:** Can be 50% replaced.
- **ABS:** Replacement is not recommended.

COMPREHENSIVE PERFORMANCE EVALUATION

From the perspective of combined whitening and flame retardant functionality, the experiments demonstrate that ZnS can partially or completely replace Sb₂O₃ as a flame retardant.

ZnS itself is a white pigment, imparting a bright tone to materials. Its whitening power is approximately equivalent to 60% that of titanium dioxide (TiO₂). Therefore, using ZnS as a flame retardant in a formulation allows for a corresponding reduction in the amount of TiO₂ required, optimizing both cost and performance.

Furthermore, ZnS is non-toxic and environmentally friendly, making it suitable for use in plastic systems such as polyvinyl chloride (PVC) and compliant with current environmental regulations for flame retardant additives.

Disclaimer

The property values presented herein are typical values and are not to be interpreted as specification limits. The information in this document is believed to be accurate and reliable as of the date of publication; however, it is provided for general guidance

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