The Performance of Flame Retardants in Rigid Polyurethane Foam Formulations

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SUMMARY

The flame retardant properties of rigid polyurethane foam compositions are determined by the type and level of flame retardant, the isocyanate index of the foam and the structure of the polyol.

Three phosphorus-based flame retardant additives are compared using the BS 4735 horizontal burn test and the DIN 4102-B2 vertical burn test in a wide range of polyol types. The results obtained are consistent with the phosphorus content of the additives. Dimethyl methylphosphonate with a phosphorus content of 25% proves to be the most effective flame retardant. Surprisingly, the chlorine content, which accounts for nearly a third of the trismonochloropropyl phosphate molecule, does not appear to exhibit any flame retardant effect above its phosphorus content. Reoflam 306, a proprietary halogen-free additive with a phosphorus content of 15-2%, enables polyurethane foams of normal index to be formulated to meet the requirements of DIN 4102-B2 without the addition of a flame retardant polyol.

Both test methods clearly showed that the aromatic-based polyols have inherently better flame retardant properties than the aliphatic-based polyether polyols.

INTRODUCTION

Polyurethane technologists are often faced with the problem of formulating a polyurethane foam for a particular application to meet a
product specification which includes some form of flammability performance. The options which the technologist has to consider, purely from the aspect of the foam alone and its flame retardance, include:

(i) the type of polyol;
(ii) whether to include a flame retardant polyol;
(iii) the isocyanate index: should it be a PUR or a PIR foam?
(iv) the type and level of flame-retardant additive to use.

This paper concentrates mainly on the latter consideration, but also shows that the type of polyol is important and should therefore be considered. Some data are also presented on the effect of isocyanate index.

Flammability test methods

Two other very important considerations are the final product construction, in which the polyurethane foam may be only part of a composite, and the flammability specification it has to meet.

The latter could be one of the small-scale ‘bare foam’ tests, which in general have been largely discredited, since they give little or no indication as to how a final product will perform in a real fire. Alternatively, it could be an intermediate-scale test, such as BS 476, Part 7,¹ or the French Epiradiateur test,² which are used in various national standards, or it may even be a full-scale test such as the FOC test.³

It has become increasingly apparent that in order to judge the likely performance in real fires it is necessary to simulate real fire situations. Almost by definition this means that such tests should be fairly large scale and, hence, undoubtedly expensive to carry out. These tests will also be carried out on the finished product, which is often a composite, e.g. a laminate board, in which case the type and thickness of the facings, how the board is fixed, how the joints are sealed, etc., can all have a significant effect on the actual flame retardant performance, as well as on the effect of the urethane foam itself.

For the polyurethane technologist, the ideal action would be to evaluate all the foam options in the final product configuration in a full-scale fire test; however, this is seldom, if ever, feasible. The technologist, therefore, has to make initial judgements on the basis of small-scale tests and experience, until he arrives at what he believes