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Thermal hazards: identify, assess, control...

Part I: Quick screening with very small amounts – along with fast help for R&D

Many processes in the chemical industry lead to the release of energy in the form of heat, which in an uncontrolled release may lead to a self-accelerating reaction. The heat that often accumulates here is a possible catalyst for additional energy-rich secondary and consecutive reactions or for the simple decomposition of the substance. This so-called thermal “runaway” often cannot be controlled through (counter-) cooling. The occurring decomposition products may ultimately lead to an uncontrolled pressure buildup with far-reaching consequences.

Differential scanning calorimetry (DSC) provides an in initial indication of the hazard potential of substances and compounds. Here, a small sample of approx. 10 mg is heated in comparison with an inert reference. Endothermal or exothermal processes are measured here as differences between the thermal release of the sample and the reference, plotted against the temperature (“Thermogram”), and enable conclusions to be drawn regarding the thermal potential of the substance. The start of the effect, known as the “onset temperature,” can be inferred from the thermogram. Figure 1 shows an example of a thermogram. On the basis of the identified“onset temperature,” a limit temperature “Texo” can be specified up to which a substance or mixture of substances is generally safe to handle. In accordance with the technical regulation for plant safety TRAS410, this limit temperature is set 100 K below the “onset temperature” of the first exothermic setting.

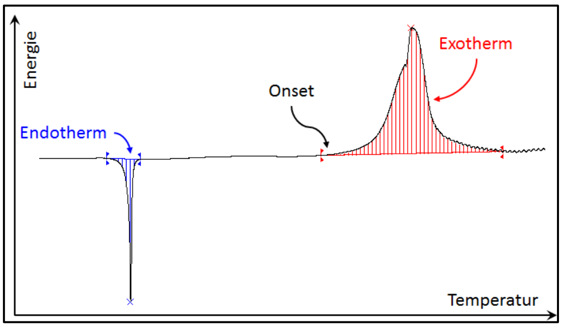

Figure 1: Thermogram

Using the thermogram, the energy content can furthermore be determined through integration of the signals. This is an important parameter for the REACH Regulation, the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) transport law and the assessment of chemical processes (TRAS410). In these regulations, limits are stated for the release of energy which, when exceeded, assume certain thermal potentials for a specific substance or mixture of substances. For instance, no explosive properties are assumed for a substance with an energy release of less than 500 J/g up to 500 °C. In our experience, an assessment of the thermal hazard potential for most of the samples tested can be conducted using these simple and quick methods – and using a minimum sample size. It is therefore the method of choice, especially at an early stage of chemical development and laboratory synthesis.

Figure 2 shows as an example the DSC for conventional sugar. First, endothermic caramelization is observed (blue segment). Starting at a temperature of about 220 °C, the exothermic decomposition can be seen (red segment). The T_{exo} is thus up to 120 °C. Consequently, sugar can be handled at a temperature of up to 120 °C without a thermal hazard. As an additional safety-related classification, sugar, with an energy release of about 450 J/g, is not viewed as an explosive substance. As this simple example shows, with about 10 mg of a substance, the significant parameters for thermal stability and additional information such as melting and boiling points can be obtained.

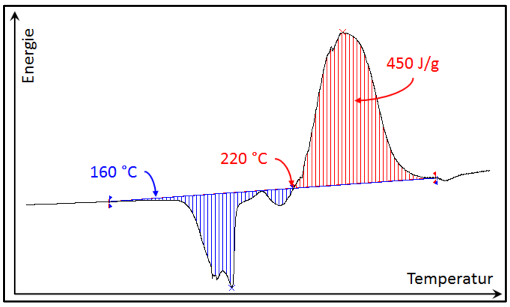

Figure 2: DSC for sugar

In the next issue we will suggest things you can do if the limit temperature Texo identified in the DSC could be exceeded in a chemical process. If we can assist you with a similar issue, please contact us. Our experts will be happy to help you.

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