

POLYOLEFINS

INFORMATION ON EMISSION FROM PROCESSING AND FIRES

Polyolefins, i.e. Polyethylene (PE) and Polypropylene (PP) can be processed by several different processing technologies. At elevated processing temperatures, thermal degradation and oxidation take place and volatile compounds (VOC) are emitted.

All information in this document applies only to Polyolefins in a number of different processing technologies, i.e. extrusion coating, blown and cast film extrusion, pipe and profile extrusion, blow moulding, injection moulding, rotational moulding, welding, sealing and shrinking film, and in fires.

THERMAL DEGRADATION

Thermal degradation is an irreversible chemical process caused by heat. Polymer chains crack into shorter chain reducing resin molecular weight, introducing double bonds in the polymer and producing low molecular weight volatiles.

Thermal degradation divides into oxidative and non-oxidative degradation. In extrusion the degradation begins in the extruder screw, under non-oxidative conditions and ends as oxidative degradation when the polymer melt reacts with atmospheric oxygen in the die area. Oxidative degradation takes place already in the screw, because small amounts of oxygen drift to the screw within the granulates. The scission of the polymer can be induced by shear or be purely thermal. When the degradation process has been initiated the end degradation products are the same regardless of the reaction pathway.

INFLUENCING PARAMETERS

Several parameters can alter the amount and nature of emissions. Among these are polymer type, additives, processing temperature and processing technology.

The polymer type determines the degradation products. Polyolefins are made up of Carbon and Hydrogen and so their degradation products are also hydrocarbons. Impurities, e.g. catalyst residues, can initiate the degradation.

Additives, mainly antioxidants, are used in Polyolefins at very low concentrations. Thus emissions generated from additives are nearly non-existent. However, antioxidants greatly influence the thermal degradation process. Thermal degradation and the amount of degradation products decrease, because the degradation process is hindered by antioxidants. In rare cases, for products containing glycerol-monostearate, as antistatic agent, in combination with inorganic fillers and where there are high extrusion temperatures the formation of acrolein has been observed. It is therefore recommended not to exceed the maximum processing temperatures as provided in the related product data sheets.

Processing temperature and Oxygen content influence the emissions. The higher the processing temperature, the more the polymer degrades. The bigger the air-exposed surface to volume ratio of the extruder, the more Oxygen-containing degradation products are formed. In extrusion coating the processing temperature is high, above 300 °C, and no antioxidants are used, because oxidation is needed to adhere the polymer to the substrate e.g. cardboard. This causes faster degradation of the polymer and higher emissions than in other processing technologies.

Processing applications and different operating conditions effect the degradation. Typical variables are extruder size and type, extrusion temperature and rate, cooling rate of the extrudate and shear effect from the extruder screw. Higher production rate increases the emissions, but decreases the total amount of emissions per kg of polymer processed. Efficient cooling decreases emissions.

EMISSION PRODUCTS IN PROCESSING

Thermal degradation products of Polyethylene and Polypropylene are mainly the same for both polymers. Polypropylene degrades easier than Polyethylene due to its structure and therefore, the total amount of emissions is a little bit higher at processing Polypropylene.

Emissions from processing are primarily different hydrocarbons, saturated or unsaturated, with linear, branched or cyclic structure. Some aromatic compounds are also generated when additives degrade, but the amounts are typically very low. The number and amount of oxygenates among the degradation products are small, but may increase with the processing temperature.

The most abundant oxygenates are Formaldehyde, Acetaldehyde, Formic Acid and Acetone. Water vapour, Carbon Monoxide (CO) and Carbon Dioxide (CO₂) are also formed. Dust and aerosols, which resemble Paraffin Wax fumes, are formed in significant amounts. The absolute amount of emissions is extremely difficult to estimate since it depends on local circumstances.

FIRES

A fire will start when an ignition source e.g. spark ignites flammable material in the presence of oxygen. A fire can also start by self-ignition at elevated temperatures.

Polyolefins burn easily, because their Oxygen index is low (17) and they have a high energy content. This leads to high heat levels and rapid propagation combustion of a fire. Polyolefins soften, melt and drip in burning droplets when they burn. This increases burning surface and promotes the spread of fire. Polyolefins generate smoke when burning. Smoke generation of Polyolefin is lesser than that of other plastics, but more intense than that of wood. In Oxygen-rich flaming fires, less smoke is generated than when the fire is smouldering.

The relative flammability of individual plastics depends not only on the polymer itself and its burning behaviour, but also on the conditions, and the size and shape of the materials involved.

EMISSION PRODUCTS IN FIRES

Since combustion tends to be incomplete in fires, a number of different combustion products, e.g. CO and soot, are formed in addition to water vapor and CO₂. The major toxic component in combustion gases in plastic fires is Carbon Monoxide. Small amounts of Aldehydes (as Formaldehyde and Acrolein), Ketones, Alcohols and Esters are also formed.

OCCUPATIONAL IMPACTS

Hundreds of different compounds are formed in processing and in plastic fires. Nearly all these compounds appear in such small concentrations that they have no practical occupational impacts. Concentrations of the individual degradation products in processing are significantly lower than their occupational exposure limits.

Carbon Monoxide is the most toxic degradation product both in fires and in processing. CO bonds the haemoglobin of blood and blocks the ability of blood to transport Oxygen around the body. This may cause intoxication and lead to unconsciousness and death. Already, rather small amounts of CO cause dizziness, headaches and fatigue.

Reported occupational health impacts in processing are mainly different temporary symptoms of irritation and allergy, and indisposition.

Aerosols are reported to be the major occupational problem in the processing of plastics, because of the irritant nature of the aerosols. Their visibility and odour can present a nuisance.

Exposure to emissions trapped inside a blown-film bubble or a sealed mould presents the greatest occupational risk in processing. However, the emissions in contained airspace dissipate to safe levels quickly e.g. after bubble-burst.

Despite the small amounts of emissions, efficient ventilation is always needed to ensure the safety of the working environment and to minimize the occupational risks.

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