VOELPKER | plastic series

TECHNICAL STUDY

Formaldehyde scavenger

Reduced ejection force

Faster part production

Improved dispersion

THE EFFECT OF CEVO® 5515 ON THE DEGRADATION OF POM:

Suppression of chain degradation and formaldehyde release

Introduction

Polyoxymethylene (POM) is an engineering thermoplastic used in precision parts requiring high stiffness, low friction, and excellent dimensional stability. POM can be easily decomposed by heat, friction, acids and oxygen during compounding, releasing undesired gaseous formaldehyde.

POM is a recyclable material and can be used to produce a wide range of products, such as automotive parts and electrical components. Recycling POM is already thermally and mechanically pre-stressed and is therefore most notably prone to degradation and releasing formaldehyde. This is particularly true for the homopolymer.

Effective additives that protect against POM degradation and the release of formaldehyde and bind split-off formaldehyde are in high demand for virgin and recycling applications. In the present study, the effect of VOELPKER's development CEVO® 5515 has been tested in different POM formulations in two different test designs: in laboratory kneading tests and tests on the extruder: The results are summarized below.

1. Lab Mixer Tests

Results

Test conditions and material

In a first step, test conditions were determined under which formaldehyde is released from unadditivated POM.

- **POM Copolymer:**
  No formaldehyde smell could be provoked at 210 °C and in the range of 50 rpm – 100 rpm.

- **POM Homopolymer/Copolymer 50:50:**
  The mixture developed a slight, but clearly preceptile formaldehyde smell at 210 °C and 100 rpm.

- **POM Homopolymer:**
  At 210 ° C and a speed of 100 rpm, a strong smell of formaldehyde was detected. The smell was already noticeable in a weaker form under the pre-drying conditions (80 °C / 4 h).

The main difference between POM Homo and POM Copo is the stability of their molecular structure. POM Homo has a linear chain of oxymethylene groups, which can be more easily depolymerized, which results in the formation of formaldehyde[3]. POM Copo has a branched chain of oxymethylene groups with, for example, ethylene oxide groups inserted randomly along the chain. These ethylene oxide groups act as stabilizers, preventing the unzipping of the polymer chain and reducing the formation of formaldehyde. Therefore, POM Copo has better resistance to degradation than POM Homo.

Test material
Hostaform® C 9021, POM Copolymer, unfilled (Celanese)
Delrin® 100 KM, POM Homopolymer, 10 % Aramide (Dupont)
Pretreatment: dried at 80 °C / 4 h

Test equipment
HAAKE™ Rheomix Lab Mixer / HAAKE™ PolyLab™ OS System torque rheometer platform[1]
Test temperature: 210 °C
Test speed: 50 rpm, 100 rpm
Filling quantity: 250 g
Duration of the kneating process: 4 min
GÖTTFERT MI-3 Melt index tester (plastometer)[2] : 190 °C/2.16 kg

[1] https://amslabo.com/product/haake-rheomix-os-lab-mixers-for-the-haake-polylab-os-system
[2] https://www.goettfert.com/products/melt-flow-indexer/mi-3

[3] https://pslc.ws/potm/pom.htm

CEVO® 5515: Suppression of formaldehyde release

Being a more sensitive system than POM Copolymer, POM Homopolymer was used for the experiments to check the effectiveness of different concentrations of CEVO® 5515 (Table 1).

The type Delrin® 100 KM (Dupont) used is filled with Aramid (Kevlar®). A higher shear stress is therefore induced on the polymer during processing and makes it even more susceptible to degradation. Delrin® 100 KM therefore appeared particularly suitable as an indicator system.

0.5 % - 1 % CEVO® 5515 suppress the release of formaldehyde and block chain degradation

Already 0.5 – 1 % CEVO® 5515 prevented the release of odor-perceptible amounts of formaldehyde from POM Homopolymer (Table 1, No. 5, 6). In addition CEVO® 5515 blocks end groups the of the POM Homopolymer and thus suppresses chain degradation and molecular weight decrease. This is also reflected in the MFR, which is quite close to the initial MFR of the thermally unstressed starting material (Table 2).

No.	POM / POM Formulation	Treatment	Result
1.	100 % Copolymer	210 °C / 50 rpm	No odor development
2.	100 % Copolymer	210 °C / 100 rpm	No odor development
3.	50 % Copolymer 50 % Homopolymer (10 % Aramid)	210 °C / 100 rpm	Slight odor development
4.	100 % Homopolymer (10 % Aramid)	210 °C / 100 rpm	Distinct pungent smell
5.	99 % Homopolymer (10 % Aramid) 1 % CEVO® 5515	210 °C / 100 rpm	No odor development
6.	99.5 % Homopolymer (10 % Aramid) 0.5 % CEVO® 5515	210 °C / 100 rpm	No odor development

Table 1

Aramid-filled POM Homo: Suppression of chain degradation with CEVO® 5515 and Preservation of MFR

No.	POM / POM Formulation	MFR 190 °C/2.16 kg [g/10 min]	Result
Starting material	100 % Homopolymer **Thermally unstressed**	2.0	Initial MFR
4.	100 % Homopolymer No additive **210 °C / 100 rpm**	3.8	Chain degradation, MFR increase
5.	99 % Homopolymer 1 % CEVO® 5515 **210 °C / 100 rpm**	2.3	Preservation of initial MFR
6.	98.5 % Homopolymer 0.5 % CEVO® 5515 **210 °C / 100 rpm**	2.2	Preservation of initial MFR

Table 2

2. Extruder Tests

Results
Test conditions and material

A 1:1 mixture of virgin POM-Homo and POM Copo regranulate already emitted a slight but clearly perceptible smell of formaldehyde on the extruder head at 188 °C. Also, the resulting warm granules smelled of formaldehyde (Table 3; No. 1.). As shown before in the laboratory mixer experiments, pure POM Homopolymer is an even more sensitive test system. Especially regranulate has been submitted to repeated shear and temperature stress in its lifetime and makes it even more susceptible to degradation. Therefore, POM Homopolymer regranulate appeared particularly suitable as an indicator system in extruder experiments.

Test material
POM-H[1] / POM-C[2] – 1:1 mixture
POM-H[3]
Pretreatment: dried at 100 °C / 3 h

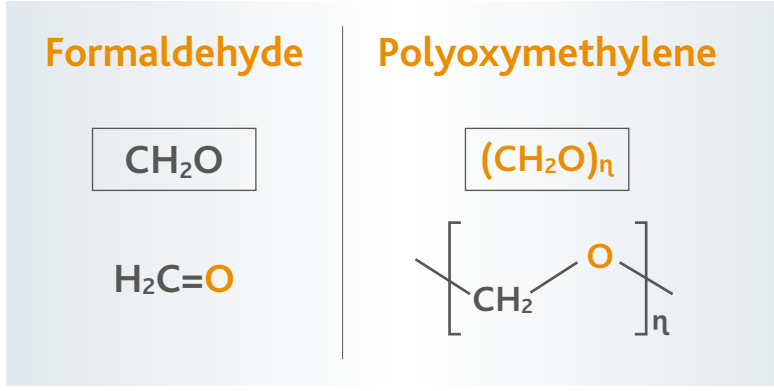
[1] Virgin POM-Homo, MVR 2.5 cm^3/10 min
[2] Regranulate POM-C, black, stabilised, MVR 2.1 cm^3/10 min
[3] Regranulate POM-H, stabilised

Test equipment
Twin screw extruder ZE25Ax47D (KraussMaffei Berstorff)
GÖTTFERT MI-3 Melt index tester (plastometer)[4] : 190 °C/2.16 kg

[4] https://www.goettfert.com/products/melt-flow-indexer/mi-3

0.5 % CEVO® 5515 suppress the release of formaldehyde also under extrusion conditions

As described above, a 1:1 mixture of virgin POM-Homo and POM Copo regranulate emitted clearly perceptible smell of formaldehyde at 188 °C. After adding 0.5 % CEVO® 5515, the smell of formaldehyde no longer appeared under the same conditions (Table 3; No. 1./2.).
The addition of CEVO® 3400, as a potential additional lubricant, had no adverse effect on the performance of CEVO® 5515 (Table 3; No. 3./4.).



No.	POM / POM Formulation	Treatment	Result
1.	100 % POM-H/POM-C Regranulate No additive	188 °C / 44 bar	Slight but clearly perceptible smell of formaldehyde on the extruder head. Smell of formaldehyde from the warm granules
2.	99.5 % POM-H/POM-C Regranulate 0.5 % CEVO® 5515	188 °C / 44 bar	No odor development
3.	99 % POM-H Regranulate 0.5 % CEVO® 5515 0.5 % CEVO® 3400	188 °C / 44 bar	No odor development; neither on the extruder head nor on the warm granules
4.	99.8 % POM-H Regranulate 0.5 % CEVO® 5515 0.7 % CEVO® 3400	188 °C / 44 bar	No odor development; neither on the extruder head nor on the warm granules

Table 3

0.5 % CEVO® 5515 suppress the release of formaldehyde and block chain degradation

The results from the lab mixer tests were confirmed: also in the extruder experiment already 0.5 % CEVO® 5515 prevented the release of odor-perceptible amounts of formaldehyde from POM Comopolymer and POM Homopolymer (Table 3; No. 2. – 4.). CEVO® 5515 blocks end groups the of the POM Homopolymer and thus suppresses chain degradation and molecular weight decrease. This is also reflected in the MVR, which is quite close to the initial MVR of the thermally unstressed starting material (Table 4).

POM Homo Regranulate: Suppression of chain degradation with CEVO® 5515 → Maintaining the MVR

No.	POM / POM Formulation	MVR 190 °C/2.16 kg [cm^3/10 min]	Result
Starting material	100 % POM-H Regranulate **Thermally unstressed**	2.2	Initial MVR
3.	99 % POM-H Regranulate 0.5 % CEVO® 5515 0.5 % CEVO® 3400	2.3	Preservation of initial MVR
4.	99.8 % POM-H Regranulate 0.5 % CEVO® 5515 0.7 % CEVO® 3400	2.4	Preservation of initial MVR

Table 4

Summary and Conclusion

The above study has shown, that CEVO® 5515 is an effective additive that protects against POM degradation and the release of formaldehyde. It is a special montan wax based additive formulation which includes an effective formaldehyde scavenger and -release blocker.
CEVO® 5515 in addition contains a finely tuned composition of esters of long-chain fatty acids with multihydroxyl alcohols and fatty acid salts and -esters.

CEVO® 5515 suppresses the polymer degradation from the chain end, responsible for the formation of formaldehyde. The formulation minimizes unwanted odors caused by the release of formaldehyde. CEVO® 5515 is suitable for POM homopolymer and copolymer and helps to maintain the melt index of thermally stressed and filled POM-H.

VOELPKER | plastic series

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