LI. Temperature Resistant Polymer Coating Systems for Frying, Cooking and Baking Utensils

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1. **Preamble**

Coating systems in the sense of this Recommendation are dispersions or solutions of artificial organic resins in water or organic solvents for producing slippery, non-stick coatings on kitchen utensils and other articles that come into contact with foodstuffs. As a rule, thickness of the coating does not exceed 60 µm. Usually, the coating consist of combinations of fine-grain homo- or copolymers of tetrafluoroethylene with solutions or dispersions of film-forming artificial organic resins. Coatings of fluoropolymers and fluoro-polymer-free coatings of artificial resins are also covered by this Recommendation. There are no objections to the use of temperature resistant polymer coating systems in the manufacture of commodities in the sense of § 2, Para. 6, No. 1 of the Food and Feed Code (Lebensmittel- und Futtermittelgesetzbuch), provided they are suitable for their intended purpose and comply with the following conditions:

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1 Artificial resins in the sense of this Recommendation are polymers obtained through modifying natural products, polymerisation, polycondensation or polyaddition, e.g. thermoplastics, thermosetting plastics and elastomers.
2. Substances for producing temperature resistant coatings

2.1 Systems for producing coatings on kitchen utensils for frying and cooking (e.g. frying pans, saucepans etc.)

2.1.1 Fluoropolymers:
2.1.1.1 Polytetrafluoroethylene,
provided its melting viscosity at 380 °C is greater than 50 Pa · s and its melting point higher than 320 °C.

2.1.1.2 Copolymers of tetrafluoroethylene with the following comonomers:
Perfluoroalkyl vinyl ether with 1 - 3 C-atoms in the alkyl group
Hexafluoropropylene, max. 5 %, based on the weight of tetrafluoroethylene copolymers.
The melting viscosity of these copolymers at 372 °C, must be greater than $10^3$ Pa · s; their melting point must be no less than 305 °C.

2.1.2 Binding resins:
2.1.2.1 Polyamide-imides:
Polyamide-imide 1 (PAI-1) = poly-N-(4,4'-diphenylmethane trimellitamide imide), produced by reaction of
4,4'-disocyanatodiphenylmethane with trimellitic acid anhydride and, as necessary,
ethleneglycol monomethyl ether
Polyamide-imide 2 (PAI-2) = poly-N-(4,4'-diphenylmethane trimellitamide imide), produced by reaction of
4,4'-diaminodiphenylmethane with benzoyl chloride-3,4-dicarboxylic anhydride
Polyamide imide 3 (trione resin) = poly-(2,4,5-triketoimidazolidino-diphenylmethano-N,N'-diphenylmethano-bis-imino-
trimellitamide), produce by reaction of the reaction product of trimellitic acid anhydride
and 4,4'-diaminodiphenylmethane with 4,4'-bis-ethoxalaminodiphenylmethane and
diphenylmethane-4,4'-diisocyanate

2.1.2.2 Polyphenylene sulfide (PPS),
produce from the conversion of equimolar parts of p-dichlorobenzene and sodium
sulfide

2.1.2.3 Polyether sulfone (PES) =
poly(oxy-p-phenylene-sulfonyl-p-phenylene), produced through polycondensation
of equimolar parts of the di-potassium salt of 4,4'-dihydroxy-diphenylsulfone with
4,4’-dichloro-diphenylsulfone.

2.1.2.4 Silicone resins, provided they comply with Section II of amended Recommendation XV.

2.1.2.5 Polyaryl sulfone, produced by reaction of 4,4'-dihydroxy-diphenyl sulfone with 1,4-
dihydroxybenzene

2 This includes coatings whose intended use involves them being heated to temperatures of up to 230 °C, or for
short periods - max. 15 min - up to 250 °C.
3 Determination after ASTM D 1238 "Flow Rates of Thermoplastics by Extrusion Plastometer", obtainable from
5 The nitrogen content of polyamide-imide-1 is 7.8 to 8.2 %.
6 The sulfur content of polyphenylene sulfide is 28.2 to 29.1 %.
7 Compare Recommendation XV. *Silicones*
2.1.3 Adhesion promoters:
Lithium polysilicate\(^8\) (lithium oxide content, max. 2.1 %)
Mixture of aluminium phosphate and phosphoric acid\(^9\)

2.1.4 Additives:
In further processing of the polymers listed under 2.1.1 and 2.1.2 the following production aids may be used:

2.1.4.1 Emulsifying agents:
- Alkyl(C\(_5\)-C\(_{15}\))phenol oxyethylates with 5 - 15 ethylene oxide groups
- Fatty alcohol (C\(_{10}\)-C\(_{20}\)) oxyethylates with 5 - 15 ethylene oxide groups
- Sodium alkyl sulfates (C\(_{10}\)-C\(_{20}\))
- Ammonium lauryl sulfate
- Copolymers of ethylene oxide and propylene oxide; ethylene oxide content, min. 10 %
- Monoethanol ammonium lauryl sulfate
- Triethanolamine olate
- Sodium, potassium and ammonium salts of the condensation product of naphthalene sulfonic acid and formaldehyde
- Sodium, potassium, ammonium and bis-(2-hydroxy-ethyl)-ammonium salts of mono- and di-esters of phosphoric acid with monohydric primary straight-chain saturated fatty alcohols of chain length C\(_{12}\)-C\(_{18}\)
- Soybean lecithin
- Perfluoro-octanoic acid and its ammonium salt
- Sodium salt of perfluoro-alkenyl-oxy-benzene sulfonic acid
- Ammonium 2,2,3-trifluoro-3-[1,1,2,2,3,3-hexafluoro-3-(trifluoromethoxy)propoxy]propanoate, max. 0.01 % in the dispersion.
- Perfluoro[(2-ethyloxy-ethoxy)acetic acid, ammonium salt, max. 0.83 % of the polymer. The substance may only be used in fluoropolymers that are processed at temperatures higher than 300 °C for at least 10 min.

2.1.4.2 Other processing aids:
- Organopolysiloxanes (silicone oil) after Section I of Recommendation XV\(^7\)
- Copolymers of acrylic acid ethyl ester after Recommendation XXII\(^10\)
- Methyl cellulose
- Ethyl cellulose
- Hydroxyethyl cellulose
- Triethylamine
- Triethanol phosphate
- Diethyl monoethanolamine
- Cerium(III)-2-ethyl-hexanoate
- Ammonium peroxydisulfate
- Ethylenediamine
- Dimethylbenzyl-octadecyl ammonium hectorite

2.1.4.3 Colorants\(^11\) and fillers\(^12\)

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\(^8\) For the transfer of lithium into food or food simulant the provisions of Commission Regulation (EU) No 10/2011 apply.
\(^9\) Coupling agents produced using chromic acid are only met occasionally nowadays; about the requirements for such coatings, see 3.3.6.
\(^10\) Recommendation XXII. “Polymers based on esters of acrylic and methacrylic acids, their copolymers, and mixtures of these with other polymers”
\(^11\) Recommendation IX. “Colorants for plastics and other polymers used in commodities”
\(^12\) Recommendation LII. “Fillers”
2.2 Systems for producing coatings on baking utensils, kitchen aids, small thermos- statically controlled electrical appliances (up to 140 °C) and covers for frying and cooking utensils\textsuperscript{13}

In addition to those listed under 2.1, the following substances may be used:

2.2.1 Copolymers of tetrafluoroethylene:
Copolymers of tetrafluoroethylene with hexafluoropropylene, provided their melting viscosity\textsuperscript{3} at 380 °C is at least 10\textsuperscript{3} Pa · s and their melting point\textsuperscript{4} no less than 225 °C.

2.2.2 Binding resins:
2.2.2.1 Polysulfone = poly-(oxy-p-phenylenesulfonyl-p-phenylenoxy-p-phenylene-isopropylidene-p-phenylene), produced through conversion of the di-sodium salt of 2,2-bis-(4-hydroxyphenyl)propane (bisphenol A) and 4,4’-dichlorodiphenyl sulfone.

2.2.2.2 Epoxy resins, produced through the conversion of glycidyl ether from 2,2-bis-(4-hydroxyphenyl)-propane (bisphenol A) and epichlorohydrin with the following cross-linking agents: melamine-formaldehyde resins, phenol-formaldehyde resins, urea-formaldehyde resins and benzoguanamine-formaldehyde resins.

2.2.2.3 Polyarylsulfone, produced by reaction of 4,4’-dihydroxy-diphenyl sulfone and 1,4-dihydroxy benzene.

2.2.3 Other auxiliary agents:
In further processing of the copolymers and binding resins listed under 2.2.1 and 2.2.2, apart from the adhesion promoters listed under 2.1.3, the following substances may also be used:
Potassium citrate
Copolymer of methacrylic acid methyl ester and 3-(2-methacycloxyethyl)-2,2-spirocyclohexyloxazolidine.

3. Requirements for the finished products

3.1 Specific migration\textsuperscript{14}

3.1.1 Test conditions for
A = coated utensils for frying and cooking, after 2.1
B = coated baking utensils, after 2.2

The migration test(s) shall be carried out three times on a single sample using another portion of food simulant on each occasion.
The fulfillment of the requirements shall be checked on the basis of the level of the migration found in the third test.
The material or article shall respect the specific migration limit already in the first test for substances for which the specific migration limit is set as non-detectable.

\textsuperscript{13} This includes coatings whose intended use involves them being heated to temperatures of up to 140 °C, or for short periods - max. 15 min - up to 180 °C.
\textsuperscript{14} Methods for determining specific migration of the substances listed under 3.1.2 and 3.2 as well as the low-molecular components after 3.2, see Part II.LI. „Untersuchung von temperaturbeständigen Beschichtungssystemen aus Polymeren für Brat-, Koch- und Backgeräte“. In: Kunststoffe im Lebensmittelverkehr. Carl-Heymanns-Verlag, Losebl.-Ausg.
Test duration and temperature: | Test foodstuff: |
---|---|
60 minutes, 95 °C (A) | distilled water |
90 minutes, 95 °C (B) | |
60 minutes, 95 °C (A) | 3 % wt. acetic acid |
90 minutes, 95 °C (B) | |
30 minutes, 200 °C (A) | test fat (standardised triglyceride, natural fats or oils) |
90 minutes, 140 °C (B) | modified polyphenylene oxide (MPPO) |

If the conditions of intended use deviate significantly from the test conditions described above, these are to be adapted correspondingly.\(^\text{15}\)

3.1.2 Limits of specific migration

In determining specific migration the following limits must not be exceeded:

- Total fluorine: 0.05 mg/dm\(^2\)
- Phenolic substances: 0.05 mg/dm\(^2\)
- Organic nitrogen: 0.02 mg/dm\(^2\)
- Primary aromatic amines: not detectable\(^\text{16,17}\)
- Formaldehyde: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Emulsifiers: in total, 0.05 mg/dm\(^2\)
- 1,4-Dihydroxybenzene: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Sodium salt of perfluoro-alkenyloxybenzene sulfonic acid: max. 0.005 mg/dm\(^2\)
- Ammonium 2,2,3-trifluoro-3-[1,1,2,2,3,3-hexafluoro-3-(trifluoromethoxy)propoxy]propanoate: 0.0002 mg/dm\(^2\)

Coatings of polyamide imides with and without the use of polytetrafluoroethylene:
- Trimellitic acid anhydride: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Trimesic acid: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Coatings of polyphenylene sulfide: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- p-Dichlorobenzene: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Coatings of polyethersulfone: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- 4,4'-Dihydroxy-diphenyl-sulfone: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- Diphenylsulfone: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
- 4,4'-Dichloro-diphenylsulfone: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011

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\(^{15}\) Commercial deep-fry equipment or food-processing machinery, for example, may be subjected to conditions of use not covered by the test conditions given.

\(^{16}\) For the release of primary aromatic amines a detection limit of 0.01 mg/kg applies to the sum of the released primary aromatic amines. Additionally, primary aromatic amines classified as carcinogens in classes 1A and 1B of the CLP Regulation (EC) 1272/2008 may not be released referred to the single substance with a detection limit of 0.002 mg/kg food or food simulant. For primary aromatic amines that are listed in Annex I, Table 1 of Regulation (EU) No. 10/2011, the limit set out there applies.

\(^{17}\) This limit refers to the migration of primary aromatic amines from the monomers and to the migration of primary aromatic amines that are formed by hydrolysis of isocyanates from polyamid-imides.
Coatings of polysulfone:
4,4'-Dichloro-diphenylsulfone: in compliance with the limit stipulated in the Commission Regulation (EU) No 10/2011
2,2-Bis-(4-hydroxyphenyl)-propane (Bisphenol A): 0.24 mg/6 dm²

3.2 Limits of low-molecular components in the finished coatings

3.2.1 Coatings of polyethersulfone:
4-Chloro-4'-hydroxy-diphenyl-sulfone: content in the finished coating: 0.05 mg/dm²

3.2.2 Coatings of polysulfone:
Monochlorobenzene: content in the finished coating: 0.08 mg/dm²

3.2.3 Coatings produced using adhesion promoters must not test positively to chromium VI. Extract from the coatings must contain no more than 0.02 mg/dm² chromium III.