APPLICATION NOTE No. 56

The Best Material for Original Eppendorf Tubes®, Tips, and Plates: Properties and Chemical Resistance of Polypropylene

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Abstract

Consumables in the laboratory should be made from a material which is able to withstand strong mechanical and thermal stress, while at the same time possessing high chemical resistance. This Application Note provides information about general properties and advantages of polypropylene, the material which is used for the manufacturing of the Eppendorf Tubes®, pipette tips, and Plates. Important quality criteria of Eppendorf products regarding raw material and production will be described. In addition, a comprehensive overview of chemical resistance of polypropylene is available.

Introduction

Reaction tubes, in single tube format as well as in plate format, are used in the laboratory for the preparation, transport and storage of solutions, as well as reaction vessels. They are frequently opened, closed, shaken, centrifuged, heated, cooled, and filled with different solvents. For all these reasons, reaction containers need to be made of a material which is able to withstand all these different challenges. The same is true for pipette tips, which are in constant contact with the sample - even though the incubation time might be much shorter compared to a vessel.

All Eppendorf tubes, tips and plates are manufactured from pure polypropylene (PP). This is also true for our biobased consumables, where only the feedstock of the polypropylene differs but not the final material of the products.
For Eppendorf twin.tec® PCR Plates, the skirt is made from Polycarbonate (PC), while the wells that hold the sample are made from PP. Low wettability, high stability and mechanical strength across a broad temperature range are the hallmarks of this plastic. Furthermore, PP is resistant to most organic and inorganic acids, bases and organic solvents used in the laboratory, and it is widely biologically inert.

In comparison with other plastics, PP has clear advantages. It is more stable and transparent than polyethylene (PE), it features better chemical resistance and lower binding of biological molecules than polystyrene (PS) and polycarbonate (PC), and it may be used across a broader temperature range than polystyrene (Table 1). These properties make PP the ideal material for a wide spectrum of applications. Comparatively low binding of biological molecules such as nucleic acids and proteins is of special importance for molecular applications.

Eppendorf consumables are made exclusively from high quality, virgin PP, which complies with FDA guidelines 21 CFR § 177.1520 »Olefin Polymers«.
Additives such as plasticizers, slip agents and biocides are present neither in the raw material for Eppendorf Tubes and Plates, nor are they used during the manufacturing process. Furthermore, the dyes used do not contain organic substances or heavy metals.

In order to guarantee premium product quality without additives or other substances, high quality injection tools are required. The very smooth surface of the tubes and plates is achieved through careful optimization of the manufacturing process. The surfaces thus show very good flow performance and low wettability, which is beneficial during sample recovery. The entire production takes place under clean room conditions, and the process, from injection to packaging, is automated. Since manual interventions are virtually unnecessary, contaminations are prevented. The lot number printed on the packaging of every product provides additional security, as each product may be traced back.

Extensive quality checks are in place prior to and during production. An initial quality control of the resin is performed, faulty material is removed, and the production tools are maintained on a regular basis. Furthermore, the final product is examined for functionality and purity.
The functionality tests for tubes include lid closure security in a boiling water bath, centrifugation stability and vapor tightness. These quality controls and tests ensure the sustained high product quality across the entire production phase.

Table 1: Comparison of properties of the materials PP and PS

	PP	**PS**	**Relevant areas of application**
Transparency	Medium	High	Transmission measurements
Temperature stability	ca. 120 °C	up to ca. 60 °C	Incubation, storage, autoclaving
Resistance to organic solvents	High	Low	Nucleic acid purification, protein analytic, compounds, assays
Mechanical strength	High	Low	Centrifugation, automation
Binding of biomolecules	Low	Low to high depending on the type	Applications using nucleic acids and proteins

Chemical resistance properties of polypropylene

Resistance of PP to numerous chemicals is listed below. For each substance, the resistance at three different temperatures (20 °C, 40 °C, 60 °C) is described. Resistance in this case means: the data are recommendations for colorless PP and were derived from the literature [1-6]. These details also apply to the colored Eppendorf reaction tubes, the black and white Microplates, as well as the OptiTrack® matrix of the Eppendorf Plates, which consists of a colored rim with alphanumeric labeling.

Please note: The chemical resistance of a plastic product is highly dependent on the specific conditions of use, including stress factors such as temperature, mechanical load, and duration of exposure.
As this chemical resistance data is derived solely from literature, users should verify the resistance under their specific conditions before use. Eppendorf provides no guarantees on accuracy, completeness, or suitability and assumes no liability for any consequences arising from its use. This Application Note is intended to serve as a guiding reference. For more information on other materials used for the manufacturing of Eppendorf consumables, see User Guide 23 [7].

Chemical substance	Mass fraction (%)	PP		
		20 °C	40 °C	60 °C
A				
Acetaldehyde (ethanal), aqueous	40	1	1	1
Acetic acid, aqueous	25–60	1	1	1
Acetic acid (pure)	100	1	1	2
Acetic anhydride	100	1	0	2
Acetone (dimethyl ketone)	100	1	1	2
Acetonitrile		1	0	0
Adipic acid (hexanedioic acid), aqueous	saturated	1	1	1
Allyl alcohol (2-propene-1-ol)	96	1	1	1
Aluminum chloride, aqueous	saturated	1	1	1
Ammonia, aqueous	30	1	1	1
Ammonium chloride, aqueous	saturated	1	1	1
Ammonium hydroxide, aqueous	30	0	0	2
Amyl acetate (acetic acid amyl ester)	100	2	0	3
Amyl alcohol (1-pentanol)	100	1	1	1
Amyl chloride (1-chloropentane)	100	3	0	0
Aniline	100	1	1	1
Aniline, aqueous	saturated	2	2	2
Aqua regia (HNO_3, concentrated HCl)		2	0	3
B				
Benzaldehyde, aqueous	saturated	1	0	0
Benzene	100	2	0	3
Benzine	100	2	0	3
Benzoyl chloride		2	0	0
Benzyl alcohol	100	1	0	2
Boric acid, aqueous	saturated	1	1	1
Bromic acid		1	0	0
Bromine, liquid	100	3	3	3
Bromo benzene		3	3	3
1,3-Butadiene	100	2	0	3
Butanol (butyl alcohol)	100	1	1	2
Butyl acetate (acetic acid butyl ester)	100	2	0	3
Butyric acid	100	1	0	0
Butyric acid, aqueous	20	1	0	0

0 = not tested 1 = resistant; several months lifetime 2 = conditionally resistant; a few weeks lifetime 3 = non-resistant; a few hours lifetime or rapid destruction
n. a. = not applicable

All values are recommendations without guarantee.

Chemical substance	Mass fraction (%)	PP		
		20 °C	40 °C	60 °C
C				
Calcium chloride, aqueous	saturated	1	1	1
Calcium hydroxide, aqueous	all	1	1	1
Calcium hypochloride, 12.5 % effective chlorine		1	1	1
Carbon disulfide	100	1	0	3
Carbon tetrachloride (tetrachloromethane)	100	3	3	3
Chloroacetic acid (mono), aqueous	85	1	1	1
Chloroacetic acid (mono)	100	1	1	1
Chlorobenzene	100	2	3	3
Chloroform (trichlormethane)	100	2	0	3
Chromic acid, aqueous	50	2	2	2
Chromic-sulfuric acid mixture		3	3	3
Citric acid	all	1	1	1
Copper sulfate, aqueous	saturated	1	1	1
Cresol, aqueous	up to 90	1	0	0
Crude oil		2	0	0
Cyclohexane	100	1	1	1
Cyclohexanol	100	1	0	2
Cyclohexanone	100	1	0	2
D				
Decahydro naphthalene	100	2	2	2
Dibutyl ether		2	0	3
Dibutyl phthalate	100	1	0	2
Dichlorobenzene		2	3	3
Diesel fuel		1	2	2
Diethylene glycol		1	1	1
Diethyl ether		2	n.a.	n.a.
Diisopropyl ether	100	2	0	3
Dimethyl ether		2	n.a.	n.a.
Dimethyl formamide	100	1	1	1
Dimethyl sulfate	100	2	0	0
Dioxane	100	2	2	2
E				
Ethanol, aqueous	all	1	1	1
Ethanol	100	1	1	1
Ethyl acetate (acetic acid ethyl ester)	100	1	2	2
Ethyl benzene	100	2	2	3
Ethylene chloride (1,2-dichloroethane)	100	2	0	3
Ethylene oxide (1,2-epoxyethane)	100	1–2	1-2	1-2 (gassing)

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n. a. = not applicable

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Chemical substance	Mass fraction (%)	PP		
		20 °C	40 °C	60 °C
F				
Formaldehyde (methanal), aqueous	40	1	1	1
Formic acid (methanoic acid)	100	1	1	2
G				
Glycerol	100	1	1	1
Glycol	100	1	1	1
Glycol, aqueous	all	1	1	1
H				
Heating oil	100	1	1	2
Heptane	100	2	2	2
Hexane	100	1	2	n.a.
Hydrochloric acid, aqueous	greater than 30	1	1	1
Hydrofluoric acid, aqueous	up to 40	1	1	1
Hydrogen peroxide, aqueous	up to 30	1	0	2
Hydrogen peroxide, aqueous	90	1	0	0
Hydroquinone (1,4-dihydroxybenzene)	all	1	1	1
I				
Iodine-potassium iodide solution	50	1	1	1
Isopropanol, aqueous	all	1	1	1
Isopropanol	100	1	1	1
K				
Kerosene	100	2	2	2
L				
Lactic acid (2-hydroxypropanoic acid), aqueous	up to 90	1	1	1
Linseed oil	100	1	1	2
M				
Mercury	100	1	1	1
Methanol	100	1	1	1
Methyl acetate (acetic acid methyl ester)	100	1	1	1
Methyl chloride (chloromethane)	100	2	0	3
Methylene chloride (dichloromethane)	100	2	3	3
Mineral oil	100	1	0	2
N				
Nitric acid, aqueous	up to 30	1	1	2
Nitric acid, aqueous	65	3	3	3
Nitrobenzene	100	1	2	3
Nitrous acid	up to 50	2	0	0
O				
Oleic acid (9-octadecenoic acid)	100	1	0	2
Oxalic acid (ethanedioic acid), aqueous	all	1	0	2

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Chemical substance	Mass fraction (%)	PP		
		20 °C	40 °C	60 °C
P				
Paraffin oil	100	1	0	2
Perchloric acid, aqueous	20	1	1	1
Petroleum	100	1	0	2
Petroleum ether	100	1	0	2
Phosphoric acid, aqueous	80	1	1	1
Phosphoric acid, aqueous	95	1	0	2
Potassium chloride, aqueous	saturated	1	1	1
Potassium permanganate, aqueous	saturated	1	1	1
Pyridine	100	2	2	2
S				
Silicone oil	100	1	1	1
Silver nitrate, aqueous	all	1	1	1
Sodium acetate, aqueous		1	1	1
Sodium hydroxide	50	1	1	1
Sodium hypochloride, aqueous	diluted	1	1	1–2
Sulfuric acid, aqueous	50	1	1	1
Sulfuric acid, aqueous	96	2	0	3
T				
Tartaric acid (2,3-dihydroxybutanedioic acid), aqueous	saturated	1	1	1
1,1,2,2-tetrachloroethane	100	2	0	3
Tetrahydrofuran	100	2	0	3
1,2,3,4-tetrahydronaphthalene (tetralin)	100	3	3	3
Thionyl chloride	100	3	3	3
Toluene	100	2	0	3
Trichloroacetic acid	100	1	1	1
Turpentine	100	3	3	3
U				
Urea, aqueous	saturated	1	1	1
V				
Vaseline		1	0	1–2
X/Z				
Xylene	100	3	3	3
Zinc chloride, aqueous	diluted	1	1	1
Zinc chloride, aqueous	saturated	1	1	1
Zinc sulfate, aqueous	diluted	1	1	1
Zinc sulfate, aqueous	saturated	1	1	1

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Literature

[1] Carlowitz, B.: Kunststofftabellen. 4. Aufl. München: Hanser, 1995. ISBN 3-446-17603-9.
[2] Plastics International. „Chemical Resistance Chart."
[3] Kendrion Kuhnke Automation GmbH, "Chemical resistance of plastics", 2015
[4] Braskem "Technical literature: Polypropylene chemical resistance", 2005
[5] LyondellBasell. „Profax and Moplen Chemical Resistance Guide ASTM."
[6] INEOS Olefins & Polymers USA „INEOS PP Chemical Resistance Guide.", 2012
[7] Chemical Stability of Consumables, User Guide No. 23, Schmidt and Grzeskowiak, Eppendorf SE.

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