STUDY ON PROPERTIES OF AROMATIC POLYAMIDES USED IN MANUFACTURING OF COMPONENTS FOR THE AUTOMOTIVE INDUSTRY

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Abstract
This is an analysis of the significant properties of aromatic polyamides used in manufacturing of technical components for automotive industry. Physico-chemical, mechanical, electrical and thermal properties were studied for polyarylamide (PAA), polyphthalamide (PPA) and amorphous semi-aromatic polyamides.

1. INTRODUCTION

In manufacturing of technical components for automotive industry, the most used types of aromatic polyamides are:polyarylamides (PAA), polyphthalamides (PPA) and amorphous semi-aromatic polyamides (PA 6-3T) [1].

Applications:

- compressors microcylinders, motor housings (PAA and PAA + 50% glass fiber).
- halogen lamp housings, electric switches, etc (PPA and PPA + 30% glass fiber)
- covers of diesel fuel filters, housings of electric switches, housings of gas or liquid flow meters (PA 6-3T).

2. POLYARYLAMIDE (PAA)

2.1. Physical properties

Polyarylamides are crystalline semi-aromatic polyamides that are especially used with a glass fiber or carbon fiber reinforcement. The moisture absorption from the air is slow and limited. For injection molded products (with very low moisture content), rehydration is recommended up to 1% (in an ambient environment with 50% RH) and 3,2% (in an ambient environment with 100% RH).

2.2. Mechanical properties

Polyarylamides have good mechanical properties, as follows:

- high impact resistance
- tensile strength
- good fatigue strength and creep resistance
- good rigidity

The glass fiber reinforcement improves the friction and abrasion performances of injection molded parts.

2.3. Chemical properties

Polyarylamides are resistant against the action of aliphatic hydrocarbons (white spirit, kerosene) and aromatic hydrocarbons (benzene, toluene, ketones, esters, ethers).

Due to their amidic groups, polyarylamides are sensitive to strong oxidants (ozone, chlorine), mineral acids (sulphuric, nitric), acetic acid and formic acid.

Also PAAs are:
- vulnerable to attack of hard bases and organic acids,
- low resistance to action of UV rays Action of UV rays leads to formation of microcraters on material's surface and whitening of material (colour is turning white) associated with decrease of mechanical properties.

2.4. Electrical and thermal properties

PAAs have good, but not exceptional, electrical properties.
Thermal ageing results in oxidation and decreasing of mechanical properties, respectively.

2.5. Processing, recycling

For processing purpose, granules are dried 12 h at 80 ºC in order to reach a moisture content of 0,3 %.

Injection molding is the most frecquently used technology and processing implies no difficulties. In order to favour the crystallization of melt into the mold, the mold cooling temperature must be maintained over 120ºC. The injection molded parts undergo mold shrinkage. In many cases, mold is provided with venting channels for discharging the gases formed during injection process.

The waste products resulted from injection process can be reused after grinding and drying.

3. POLYPHTHALAMIDE (PPA)

3.1. Physical properties

The polyphthalamides are semi-crystalline thermoplastic materials with good dimensional stability due to their property of absorbing small quantity of moisture from atmosphere. The moisture absorption is slow (0,21% in 24h) and the swelling is minimum (the water content is 0,3-0,5% after keeping PPA immersed in water one year long).

3.2. Mechanical properties

The mechanical properties are not influenced by humidity/moisture.
PPAs have:
- good impact and tensile strength, fatigue and creep resistance.
- good rigidity

3.3. Chemical properties

Polyphthalamides are resistant against the action of organic solvents, aqueous solutions and fluids used in automotive industry.
Also PPAs are:
- sensitive at phenols and hard acids.
- sensitive to action of UV rays if not protected with carbon black.

3.4. Electrical and thermal properties

PPAs have good electrical properties. The thermal resistance of PPAs is high, as indicated by the value of vitrification temperature. Conversely, the temperature increase results in decrease of rigidity.

PPAs products can be repeatedly sterilized.

3.5. Processing, recycling

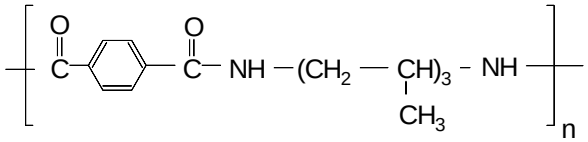
Prior to processing, granules are dried 10 h at 135ºC in order to reduce their moisture content to 0.1%.

Processed by injection molding without difficulties during the injection molding cycle. The mold temperature is raised to 135ºC in order to favour the crystallization from melt of PPA. The shrinkage occuring during molding process is important, as for all the crystalline thermoplastic materials (1,5%). In case that PPA is reinforced with 30% glass fiber, the mold shrinkage decreases to 0,4-0,8%.

After grinding and drying, the waste products resulted from injection process can be recycled only mixed with virgin material (the maximum percentage of recycled material into the mix can be 25%).

4. AMORPHOUS SEMI-AROMATIC POLYAMIDES (PA 6-3T)

The amorphous semi-aromatic polyamide (PA 6-3T) is obtained from trimethyl hexamethylene diamine (TMD) and terephthalic acid (TPA) resulting the following chemical structure:



4.1. Physical properties

PA 6-3T is an amorphous thermoplastic material with a high vitrification temperature (T_g ≈ 150ºC). It is a transparent material The low percentage of moisture absorbed from atmosphere determines a good dimensional stability.

4.2. Mechanical properties

PA 6-3T has good mechanical properties which are not influenced by the moisture percentage. - good resistance to cracking compared with other amorphous thermoplastics. - can be reinforced with glass fiber (max 60%).

4.3. Chemical properties

Good resistance to attack by hydrocarbons, but PA 6-3T is sensitive to aliphatic alcohols, methylene chloride and ethylene glycol. - can be used for containers destined for food packaging (excepting alcohols).

4.4. Electrical properties

PA 6-3T has good, but not exceptional, electrical properties.

4.5. Processing, recycling

For processing purpose, granules are dried into a drying stove till the moisture content is below 0,1%. PA 6-3T is processed as all the amorphous thermoplastics, considering the injection molding as its main processing technology.

For injection molding, the mold temperature is 60-90ºC for pure material (PA 6-3T) and 120ºC for reinforced material (PA 6-3T and glass fiber).

Extrusion technology is used to produce profiles, sheets and films. PA 6-3T can be processed through extrusion blow molding in order to produce recipients, etc

Recycling is done by equally mixing grinded material of waste products with virgin material (50% + 50%).

5. COMPARISON BETWEEN PROPERTIES OF AROMATIC POLYAMIDES. ADVANTAGES AND DISADVANTAGES

Some physical, mechanical, thermal and electrical properties for several types of aromatic polyamides are presented in Table 1 [2-10].

Table 1. Properties of aromatic polyamides

Properties	Unit	PAA + 50%GF	PPA	PPA + 30%GF	PA 6-3T
Density	Kg/m^3	1640	1150	1460	1120
Water absorption in 24h at 23ºC	%	0,16	0,68	0,21	
Water absorption at equilibrium, 50%RH	%	1		1,8	7,8
Breaking strength	MPa	250	76	221	87
Break elongation	%	1,9	6-30	2,5	8-50
Flexural strength	MPa	380	128	317	135
Compressive strength	MPa	200		276	
Tensile elastic modulus	MPa	20000	2400	13100	2800
Flexural modulus	MPa	18000	2600	11400	
Melting temperature	ºC	235	310	310	260-310
Vitrification temperature	ºC	85	127	127	149
Continuous resistance temperature interval	ºC	<140-145		<165 - 180	
Mold shrinkage	%	0,1-0,7	1,5	0,4-0,8	0,4-0,7
Thermal conductivity	W/mK	0,55		0,34	
Transversal resistivity	Ωcm	10^{16}		10^{15}	10^{15}

Advantages of aromatic polyamides:

- good mechanical behaviour
- products can be used within a wide temperature interval
- good dimensional stability

Disadvantages of aromatic polyamides:

- low fire-resistance
- expensive
- the mechanical properties are affected when the products are kept in a water-saturated atmosphere for a long time.

6. CONCLUSIONS

The present study targeted on the main properties of the aromatic polyamides used in manufacturing of technical components for automotive industrye.

The following aromatic polyamides were studied:

- polyarylamides (PAA),
- polyphthalamides (PPA)
- amorphous semi-aromatic polyamides (PA 6-3T).

All three types of materials prove physical, mechanical, chemical and thermal properties that make them suitable for manufacturing of technical components for the automotive industry.

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