PRODELEC

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JARYLEC

Dielectric liquid for capacitors

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1. INTRODUCTION

Jarylec launching was disclosed during 1982 CIGRE session[1] ; the initial trade name was switched in 1984 to its present brand name.

Today, Jarylec is one of the main capacitor fluids in the world, which belong to the last generation of dielectric fluids. It is sold by ATOFINA / Prodelec in more than twenty different countries.

Since 1982 and since the issue of the first Jarylec pamphlet, many additional data have been obtained concerning this liquid and its use in capacitors.
It was found necessary to make an up-to-date review of these data.

2. JARYLEC COMPOSITIONS

Basically, Jarylec is a blend of phenyl-tolylmethane (monobenzyl-toluene : MBT) and phenyl/benzyl-tolylmethane (Dibenzyl-toluene : DBT).

In the scientific publications this blend is identified as M/DBT which stands for Mono/Di Benzyl-toluene.

The Jarylec chemical composition is :

Benzyl-toluene	75 % ± 5 %
Dibenzyl-toluene	25 % ± 5 %
Tri/tetrabenzyl-toluene	< 4 %

This basic composition is known under the trade name of Jarylec C100.
In fact, almost all Jarylec users buy the fluid containing an epoxide as additive. This Jarylec is named : Jarylec C101. It contains less than 1% of a cycloaliphatic epoxy compound.

Prodelec laboratory has shown[2] the efficiency of epoxide to improve the all-film capacitor life at elevated temperature.

Lastly, Prodelec has patented and developed a new type : Jarylec C101 D, a Jarylec C101 to which is added a very small amount (200 ppm) of ethyl-vanillin. It further increases the capacitor life and clearly changes and improves the smell of the liquid.

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[1] CIGRE Report 15-82(WG-02) - Jay-1 : "Ugilec C100 - A non-chlorinated hydrocarbon liquid for high voltage capacitors".

[2] I.E.E.E. Trans. Elect. Insul. Vol. El-21, n° 1 (Feb. 1986), pp. 59-623 : "A new impregnant for HV power capacitor" N. Berger and P. Jay.

3. GENERAL PROPERTIES

Jarylec is a slightly yellow liquid which displays a blue fluorescence when properly lighted.

Jarylec main typical properties are summarized in the tables **1**, **2** and **3** hereafter.

TABLE 1 : PHYSICAL PROPERTIES OF JARYLEC

PROPERTY	TEST METHOD	UNIT	TYPICAL VALUE	REMARK
Color	ASTM D2129	APHA	< 70	
Refractive index	ISO 5661	-	1.578	
Specific gravity at 20°C 100°C	ASTM D1810	g/cm^3	1.01 0.95	See Fig. 1
Thermal expansion coefficient (20 - 100°C)	ASTM D1903	-	7.4×10^{-4}	
Cinematic viscosity at 20°C -30°C	ISO 3104	mm^2/s	6.5 100	See Fig. 2
Pour point	ISO 3016	°C	< -65	
Vapor pressure at 20°C 100°C	(1)	torr	2.5×10^{-3} 1.0	See Fig. 3
Water solubility at 20°C	CEI 814	µg/g	300	See Fig. 4
Gas solubility at 25°C : N2 O2	ASTM D2945	% Vol/Vol	3.7 1.9	
Surface tension at 80°C	ASTM D 3825	dynes/cm	31	
Specific heat at 20°C	ASTM D 2766	J/g/K cal/g/K	1.6 0.39	
Thermal conductivity at 20°C	ASTM D 2717	W/m/°C	0.13	

(1) Static method ref : "Université Claude Bernard Lyon I"

TABLE 2 : FIRE AND CHEMICAL PROPERTIES OF JARYLEC

PROPERTY	TEST METHOD	UNIT	TYPICAL VALUE	REMARK
Flash point	ISO 2592	°C	144	
Fire point	ISO 2592	-	154	
Combustion heat	ASTM D2945	kJ/g	40	
Oxygen index	NFC 27250	-	18	
Auto-ignition temperature	84/449/EEC Test A15	°C	459	
Water content	CEI 814	µg/g	40	
Acid number	CEI 867 § 5.6	mg KOH/g	< 0.01	(1)
Epoxide concentration	see enclosure	mg HCl/g	1.9	(2)

(1) The acid number of Jarylec C101D (0.06) corresponds to the presence of the additive.
(2) Only for Jarylec C101 and C101D.

TABLE 3 : ELECTRICAL PROPERTIES OF JARYLEC

PROPERTY	TEST METHOD	UNIT	TYPICAL VALUE	REMARK
Permittivity at 25°C	IEC 247	-	2.66	See Fig. 5
Dissipation factor (50Hz-90°C)	IEC 247	-	0.001	See Fig. 6
Volume resistivity at 90°C	IEC 247	Ω x cm	10^{14}	
Breakdown voltage	IEC 156	kV	90	
Gassing property	IEC 628-A	µl/mn	-174	

Figure 1

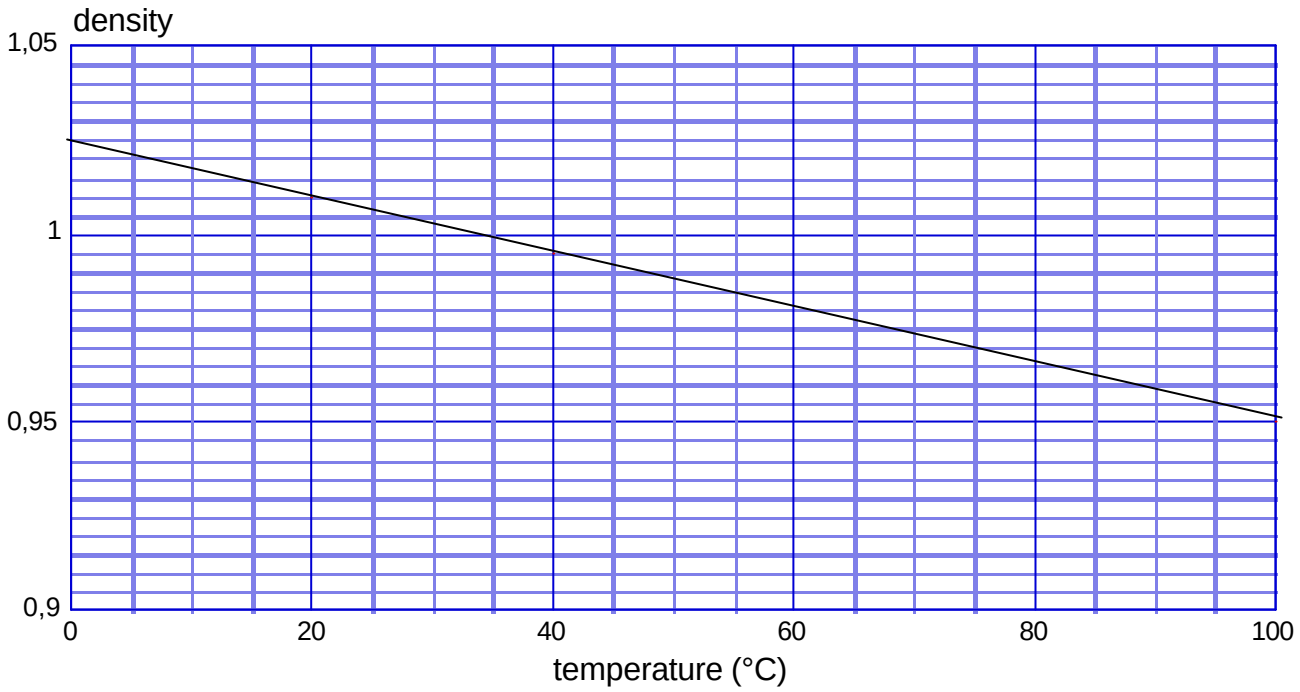


Figure 2

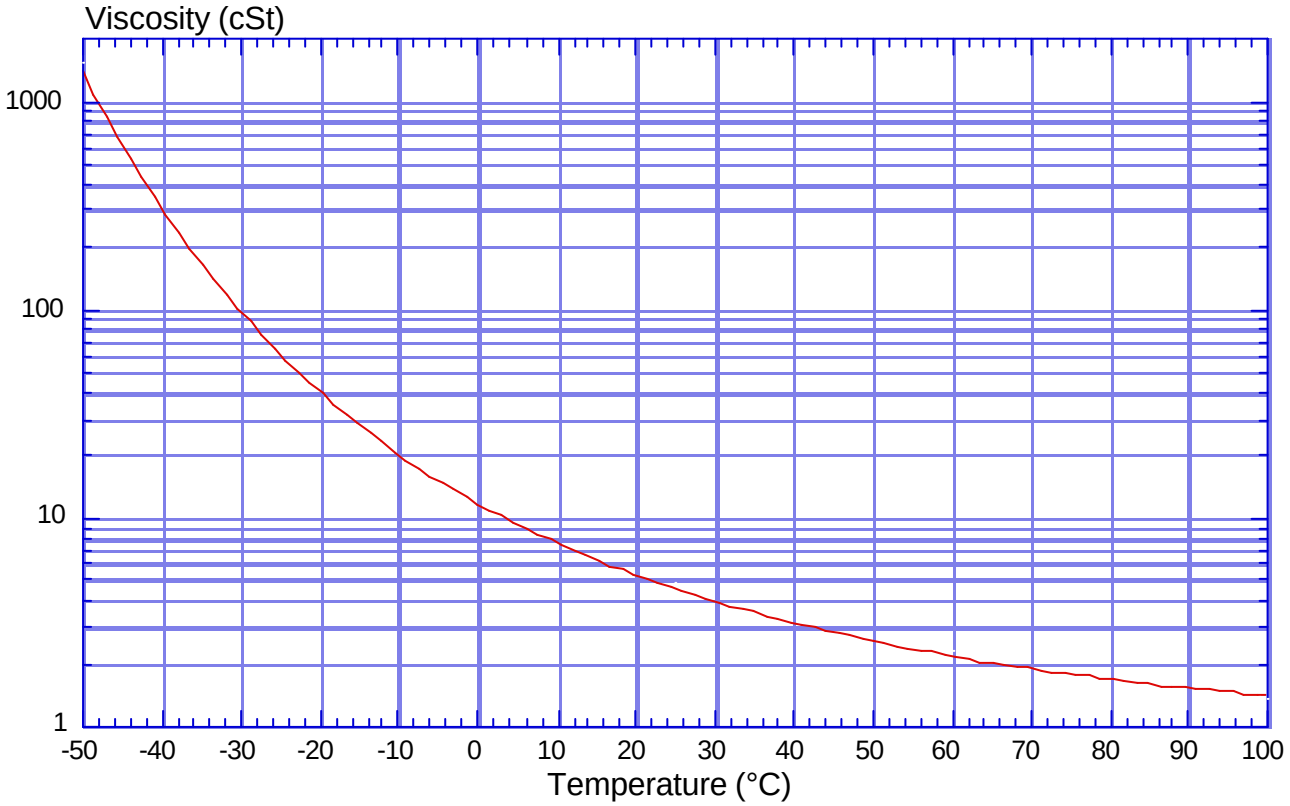


Figure 3

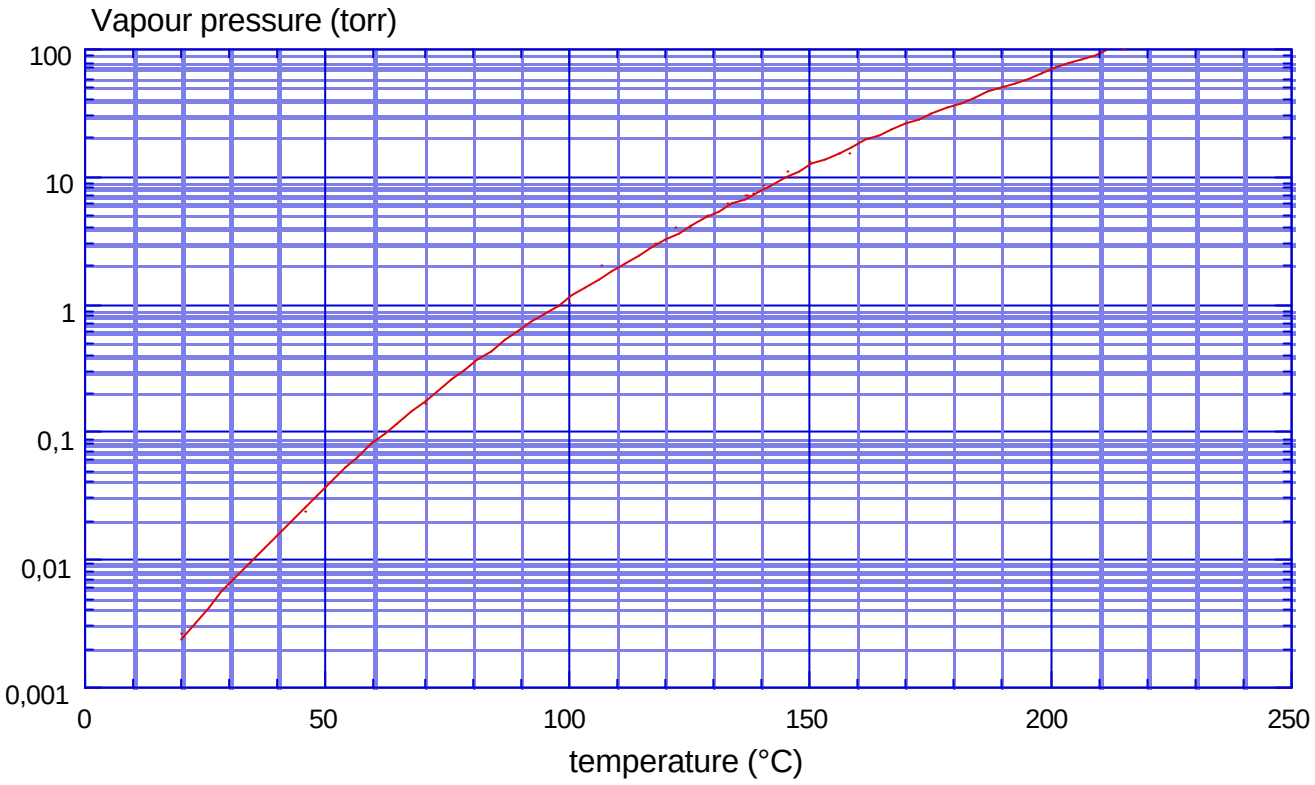


Figure 4

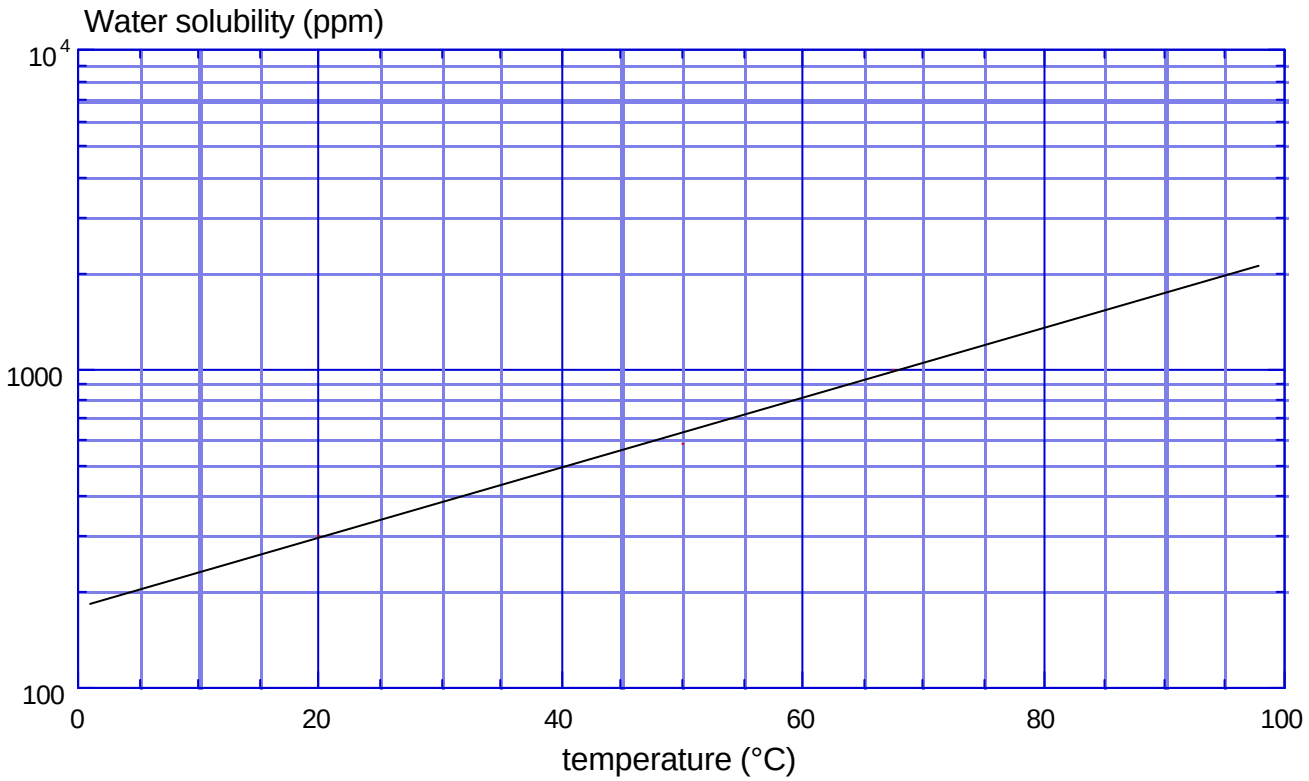


Figure 5

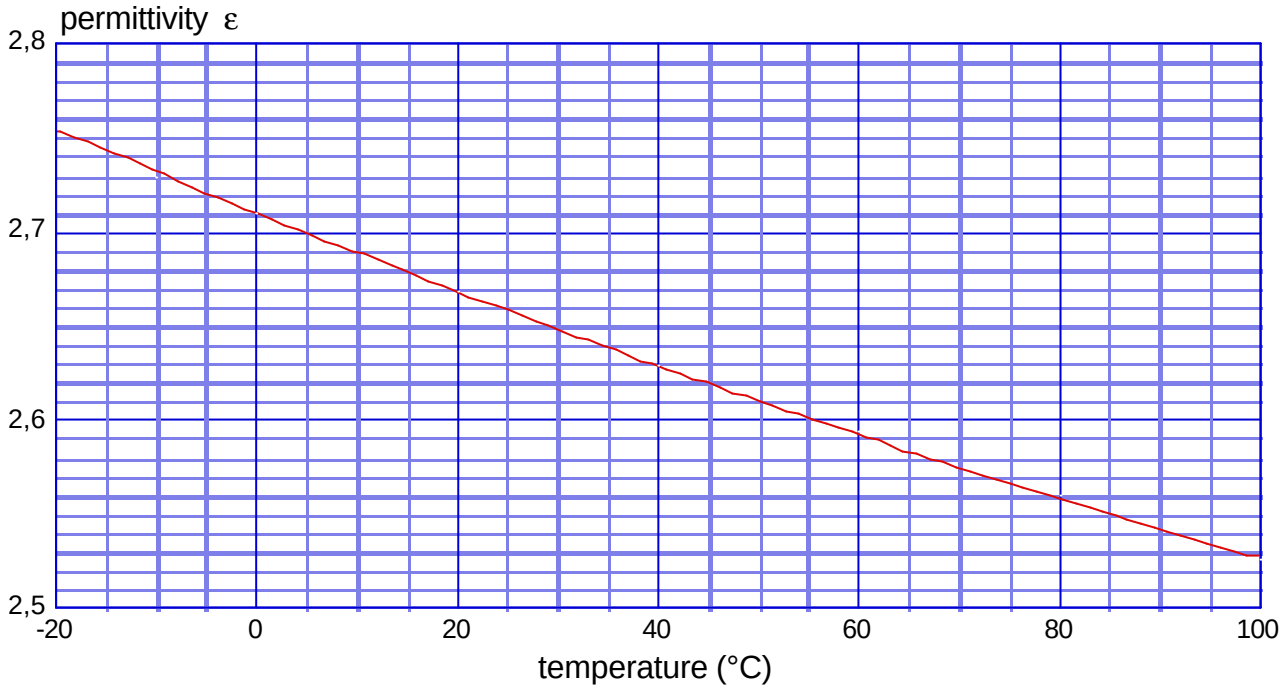
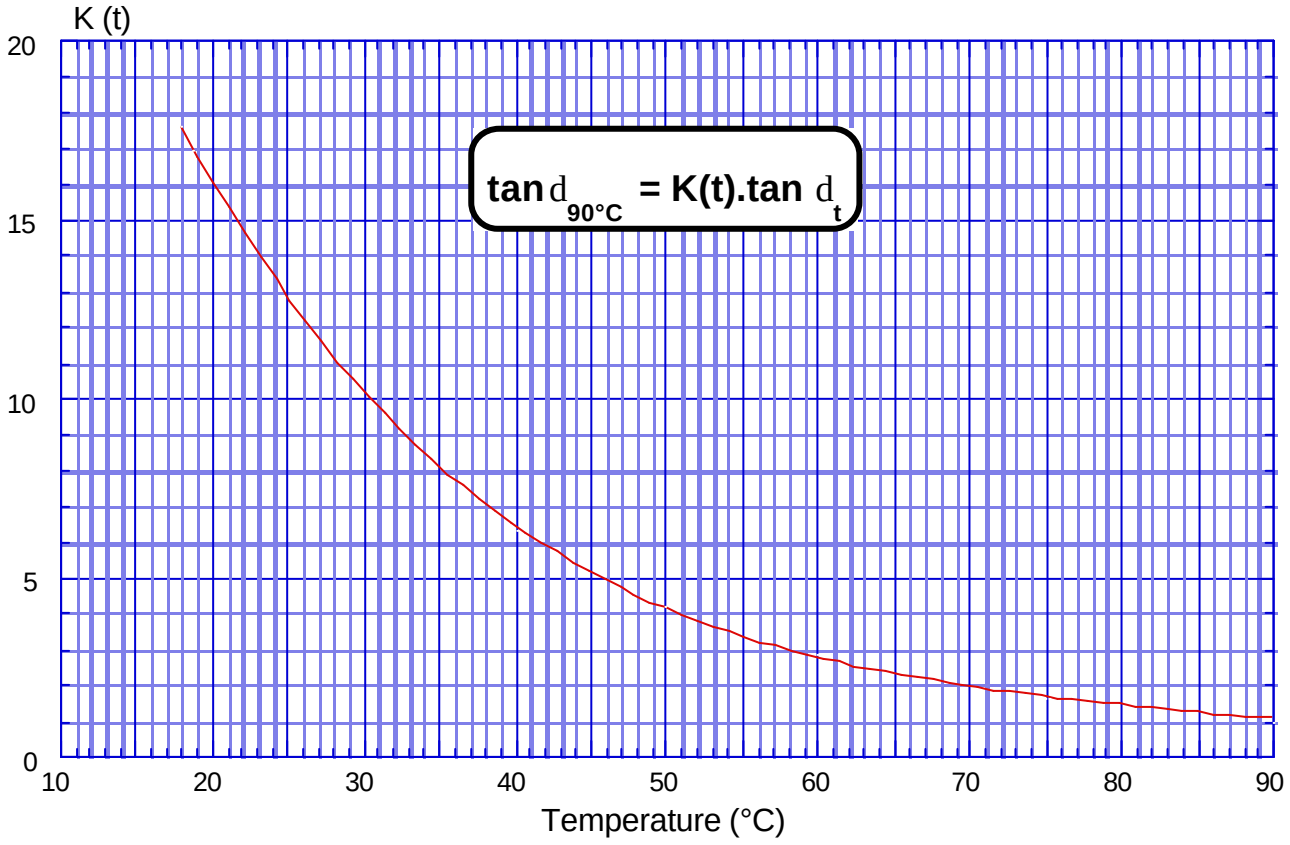


Figure 6



4. TOXICOLOGICAL DATA

Jarylec constituents, benzyl-toluene (BT) and Polybenzylatedtoluene (PBT) are known chemical liquids.

In USA, these compounds are listed in the official TSCA inventory under the CAS numbers : 27776-01-8 and 26898-17-9.

In Europe, the EINECS classification numbers are : 2486548 and 2480970.

In France, Jarylec is classified as mineral oil, in particular for its disposal.

In Switzerland, Jarylec has been classified by Federal Office for Toxic as a "5 S" product (sales authorized to the public).

Toxicological properties of Jarylec are summarized hereafter. They apply to all Jarylec types : Jarylec C100, C101, and C101D. More information is available in “JARYLEC C100, C101 and C 101D – TOXICITY SUMMARY”

Acute toxicity on rats

The tests were run on male and female rats following the EEC Directive 84/449 Enclosure V-B1 instructions.
The Lethal Dose 50 (LD_{50}) is 3200 mg/kg.

==> Jarylec is neither classified as toxic nor harmful.

Local tolerance on rabbit skin

This study was performed on "New Zealand" rabbits, following the EEC Directive 84/449 Enclosure V-B4 instructions.

==> Jarylec is non irritant.

Local tolerance on rabbit eyes

The tests were run on "New Zealand" rabbits in accordance with the ETAD method n°3 and EEC Directive 83/467 instructions.

==> They show that Jarylec is non irritant.

Acute percutaneous toxicity on rabbits

The tests were performed according the AFNOR Standard : NFT 03-033.
The LD 50 value by percutaneous route at 14 days is superior to 2000 mg/kg (maximal quantity that must be applied according this method).

==>Jarylec is not toxic or harmful.

Acute inhalation toxicity

The acute toxicity of benzyltoluene and dibenzyltoluene vapors generated at 70°C were tested in rats. Exposure duration was 4 hours and the maximum concentrations reached were 1,88 and 0.24 mg/l respectively. No mortality, toxic effect or decrease of the body-weight was observed.

==>Jarylec vapors are not toxic or harmful.

Sub-chronic toxicity on rats

The toxicity was assessed in a sub-chronic (120 day) oral toxicity study with rats.
On the basis of the results, the no-effect level for Jarylec can be estimated at 50 mg/kg/day.

Toxicity of thermal decomposition product

The toxicity of the fumes resulting from thermal decomposition of Jarylec under air, was evaluated under conditions recommended by the EEC for hydraulic fluids used in the mining equipment. It was concluded that the fumes of thermal decomposition of Jarylec is not expected to generate over-toxicity. However a transient respiratory irritation may occur.

Mutagenic potential : AMES test

The study was performed according to the US FDA (**F**ood and **D**rug **A**dministration), Japan Ministry of Health and Welfare, and OECD number 471 guide-lines.

==> Jarylec exhibits no mutagenic potential.

Mutagenic potential : Micronucleus test

This test was performed on mice.

==> Jarylec shows no evidence of mutagenic potential nor bone marrow toxicity.

Sensitizing potential

The study was performed by topical applications in the guinea pig.

==> Jarylec shows no evidence of sensitizing potential.

5. ECOTOXICOLOGICAL DATA

Jarylec solubility in water is very low : 60-240 µg/l (solubility depends on the water purity, the higher the purity, the lower the solubility).

Test performed with ^{14}C labeled molecules at a concentration of 240 µg/l show no toxicity on Daphnia magna.

Acute toxicity tests performed on fish, Daphnia, bacterium and alga, with the addition of a solvent to increase voluntarily the content of Jarylec in water, show CI50 or CL50 values much higher than the solubility limit.

Jarylec is not “readily biodegradable” due to its very low water solubility. However tests show that 76% biodegradation is reached in 48 days and full degradation after 5 month.

6. RECOMMENDATION FOR STORAGE AND HANDLING

Transport

Jarylec is not regulated by any transport regulations : road, river, ADR/RID, sea or air transport. It does not need any special labeling. It is not classified as dangerous.

Storage

Jarylec can be stored in plain steel vessels. There is no risk of degradation during storage. However to avoid contamination by air which could increase the liquid conductivity and water content, it is recommended to store the product under nitrogen or under vacuum.

Fire Hazards

In case of fire reaching vessels or equipment containing Jarylec, the recommended extinguishing agents are : Carbonic anhydride, foams, chemical powders.

Even if the toxicity of pyrolysis products is very low (lower than for mineral oil for example), it is recommended that firemen be equipped with autonomous insulating breathing equipment, since carbon monoxide may be formed in case of incomplete combustion.

Handling

- As it is generally indicated for organic products with high boiling points, breathing concentrated vapors or fumes for a long period should be avoided.

- Due to the low toxicity of Jarylec, there is no limit value officially recommended by governmental authorities. However a concentration limit of 1000 ppm in the working atmosphere sounds sensible.

It is generally considered that there is no specific measure to be taken if the concentration in the atmosphere is lower than 0.2 times the limit value. Therefore if the concentration is above 200 ppm, a vapor aspiration system is recommended.

- Contact with eyes and skin should be prevented : gloves and goggles should be worn (as well as a mask if the liquid is hot).
  In case of contact, wash thoroughly with water.

- In case of leakage : Do not let the product enter into drains. Contain by damming. Pump into an inert labeled emergency container. Absorb the remainder with an inert absorbent material.

Disposal

It is recommended to destroy the product by incineration : it is considered as an ordinary fuel oil.

Enclosure

DETERMINATION OF EPOXIDE EQUIVALENT

1. Principle

The method involves titration of the oxirane oxygen in glacial acetic acid with a standard perchloric acid solution to a crystal violet end-point.

The titration is carried out in an excess of quaternary ammonium bromide, which, on contact with perchloric acid, produces hydrogen bromide. The hydrogen bromide, in turn, reacts with the oxirane oxygen.

2. Reagents

- Glacial acetic acid.
- chloroform.
- Perchloric acid solution - O.1N in glacial acetic acid.
  (Standardize against potassium hydrogen phthalate).
- Crystal violet - 1% solution in glacial acetic acid.
- Tetraethyl ammonium bromide solution - dissolve 100 g in 400 ml of glacial acetic acid.

3. Apparatus

- 10 ml burette.
- Usual laboratory glassware.

4. Procedure

- Weight 15 to 20 g of Jarylec C101 to the nearest 0.05 g into a 125 ml Erlenmeyer flask.
- Add 10 ml of chloroform, 40 ml of glacial acetic acid and 10 ml of the tetraethyl ammonium bromide solution and swirl to dissolve.
- Add 1 drop of crystal violet indicator and titrate with 0.1N perchloric acid to the greatest color change (violet to green-blue).

5. Calculation

$$\text{Hydrogen chloride equivalence (mg/g)} = \frac{36.5 \times V \times N}{W}$$

Where V = Volume of perchloric acid (cm^3)
N = normality of perchloric acid
W = weight of sample (g)

6. Additional notes

— The titrant is very stable and does not require frequent re-standardization.
— No blank correction should be required if good quality reagents are used.