LUPEROX® RTM

Crosslinking Peroxide

Introduction

Luperox RTM® crosslinking peroxide is a solid, room-temperature stable peroxide mixture designed for fast melting and efficient crosslinking. The mixture is composed of di(tert-butylperoxyisopropyl)benzene, together with triallyl cyanurate (TAC) and a proprietary scorch protection additive. This system provides excellent crosslinking of high-density polyethylene for rotational molding applications. As a one-component system, users may also eliminate the need for separate additions of peroxide and coagent by using Luperox RTM® to achieve accurate metering.

Standard Sales Specifications

assay	36.0 – 38.0 %
active oxygen	3.40 – 3.59 %
melting point	108°F (42°C)

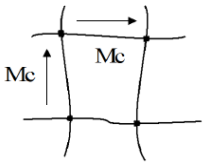
Typical Physical Properties

density	1.025 g/cm³ (45°C)
SADT	194°F (90°C)
flashpoint	> 212°F (> 100°C)

Applications

Luperox RTM® was specifically designed to replace DYBP (2,5-dimethyl-2,5-di(t-butylperoxy)hexyne-3), commonly used in rotational molding. DYBP carries a subsidiary explosive rating, and also warnings for hygiene related to acetylenic primary skin irritants. Additionally, using Luperox RTM® can reduce odor and produces better color in crosslinked HDPE articles as it does not produce these acetylenics when used.

Arkema internal lab studies compared the crosslink density of rotationally molded HDPE processed at 190°C using Luperox® RTM and a DYBP + TAC system. The results of the study are shown in the table below. The following method was used:



$$Mc = \frac{\rho * R * T}{G\gamma_{=0}}$$

Mc= average molecular weight between crosslinks (g/mole)
ρ= polymer density at experimental temperature (g/cm³)
R= Universal gas constant (8.31447 E7 (ergs/mole°K) where erg = dyne-cm; thus R can be described as (dyne-cm/mole°K)
T= crosslinking temperature in °K (Kelvin)
Gγ= the value of the equilibrium shear modulus in dynes/cm² at shear rate of zero. This was approximated using low 5% strain and a frequency sweep, extrapolating to a low frequency of 0.001 radians/sec or 0.00016 Hertz.

Absorption – High Intensity Mixer (Preferred)

- Luperox® RTM has excellent compatibility with HDPE
- Used in all HDPE, LDPE, LLDPE Grades for rotomolding
- Also UHMWPE for Ram Injection Molding
- Lower MFI grades (e.g. 5 MFI) can be used

Melt Blending (Required for DYBP)

- Luperox® RTM can also be melt blended in an extruder
- Monitor temperature/residence time to avoid scorch
- DYBP must be melt blended
- DYBP is incompatible with HDPE
- Melt blending can only use resins > 15 MFI

Wt% of Luperox® RTM vs. Crosslink Density (MH-ML) in dN-m and Molecular Weight between Crosslinks (Mc) in g/mole

Wt% added in HDPE	Peroxide Blend	MH-ML in dN-M (Torque)	Mc in g/mole (MW)
0.80%	Luperox® RTM	5.28	30132
1.00%	Luperox® RTM	6.89	17837
1.00%	**0.4% DYBP & 0.6% TAC**	**7.36**	**15990**
1.05%	**Luperox® RTM**	**7.50**	**16035**
1.10%	Luperox® RTM	7.75	14810
1.20%	Luperox® RTM	8.33	13178
1.40%	Luperox® RTM	9.82	10481
1.60%	Luperox® RTM	11.28	8988

At a loading of 1.05%, Luperox® RTM yields the same crosslink density and better torque performance than a 0.4% DYBP & 0.6% TAC blend. Together with the safety features discussed on the next page, Luperox® RTM is an excellent choice for crosslinking of HDPE in rotational molding applications.

LUPEROX® BY ARKEMA

LUPEROX® RTM

Crosslinking Peroxide

Safety Information

Luperox® RTM was designed with worker safety in mind. Based on various safety tests, Luperox® RTM presents lower hazards than DYBP (2,5-dimethyl-2,5-di(t-butylperoxy)hexyne-3, tested at an assay of 93%). The specific results of key safety tests performed on Luperox® RTM and DYBP by Arkema R&D staff is provided below.

Modified Trauzl Test (UN Test F.4)
Luperox® RTM provided a 1.9 cc volume expansion, versus 26 cc for DYBP, 93% assay. This is a test to quantify the explosive power of a peroxide, using the volume of expansion of a calibrated lead block that contains peroxide, initiated with a blasting cap. Luperox® RTM is rated as “No” explosive power, compared to “High” explosive power for DYBP.

Flash Point (Method: Seta Closed Cup)
Luperox® RTM has a Flash point > 100°C; versus 87° C for DYBP.

Koenen Test (UN Test E.1)
The Koenen Test is “Heating under Confinement”. It is a thin wall pipe-bomb test (1 mm wall thickness) with small “mm” diameter vent sizing.
Luperox® RTM = “LOW” rating
DYBP = “VIOLENT” rating

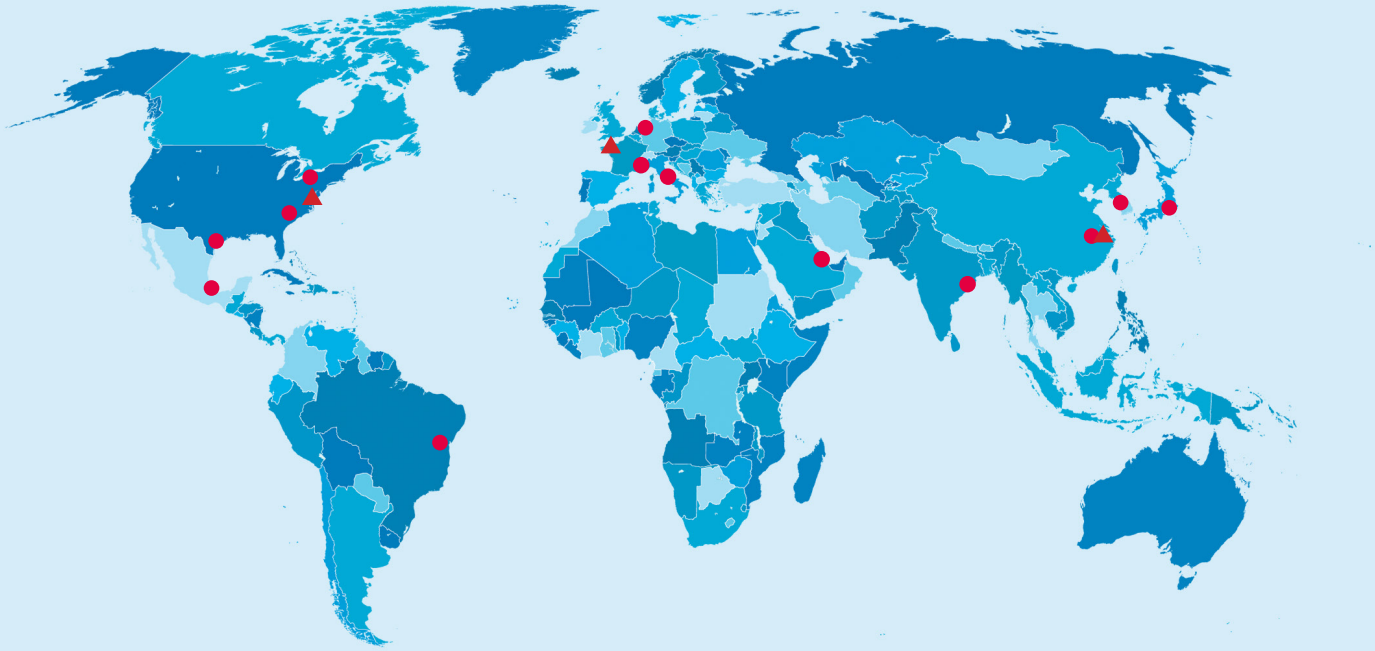
Dutch PVT (UN Test E.2)
The Dutch PVT is “Heating under Confinement” The test heats peroxide very fast at 3.5°C/sec.
Luperox® RTM = “LOW” passed a 3.0 mm
DYBP = “VIOLENT” rating

Onset Temperature of Uncontrolled Decomposition
This is the onset temperature of uncontrolled decomposition where self-heating occurs at 1°C/minute during the RHDT test. The RHDT test uses 1 gram peroxide sample in a test-tube in a heating block along with another test-tube containing 1 gram of light mineral oil, and recording the temperatures while the block is heated 4°C / minute. The Onset Temperature for Luperox® RTM is a higher, more desirable temperature of 131°C, compared to the significantly lower Onset Temperature for DYBP of 112°C

Worker Air and Skin Hygiene
The decomposition of DYBP produces various acetylenic by-products that are primary skin irritants. In contrast, Luperox® RTM is based on di(t-butylperoxy)diisopropylbenzene which does not contain an acetylene complex and therefore does not cause these by-products. Proper personal protective equipment should be worn when working with any chemical compound. Please consult the safety data sheet for additional information.

LUPEROX® BY ARKEMA

Luperox® Organic Peroxides Worldwide



● Organic Peroxides Plants
▲ Research Centers

● Piffard, NY
Franklin, VA
Crosby, TX
Coatza, MX
Rio Claro, BR

▲ King of Prussia, PA

● Gunzberg, DE
Spinetta, IT
Anagni, IT
Jubail, KSA
Cuddalore, IN
Jinhae, KR
Fukuoka, JP
Changshu, CN

▲ Pierre-Benite, FR
Changshu, CN

Arkema France - A French "société anonyme", registered in the Nanterre (France) Trade and Companies Register under the number 319 632 790
NA-Marcom -bc/pp- 1-2016

ARKEMA
INNOVATIVE CHEMISTRY

+01 844 LUPEROX

luperox.com

Arkema Inc.
900 First Avenue
King of Prussia, PA 19406
USA
Tel.: (+1) 610 205 7000

Arkema (China) Investment Co., Ltd. - Shanghai
6/F Block 1, Life Hub@Daning
1868 Gonghexin Road
200072 Shanghai, China
Tel: (+86) 21 6147 6888

Headquarters: Arkema France
420, rue d'Estienne d'Orves
92705 Colombes Cedex – France
Tel.: +33 (0)1 49 00 80 80
Fax: +33 (0)1 49 00 83 96
arkema.com