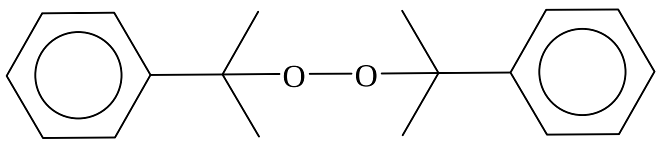
### Vulcanizing Agent and Crosslinking Agent

Di-Cup® dicumyl peroxide is used as a high temperature catalyst in the rubber and plastics industries. Compounds containing Di-Cup® are normally processed at temperatures up to 250°F (121°C) and can be cured at temperatures above 300°F (149°C).

### Grades

Di-Cup® dicumyl peroxide is available in pure form or as supported grades (40% peroxide on an inorganic substrate or as a rubber Masterbatch). The molecular weight of dicumyl peroxide is 270; its structural formula is below.




Di-Cup® R dicumyl peroxide, a pale yellow to white granular solid, melts at 100°F (38°C). Di-Cup® 40C and Di-Cup® 40KE are free-flowing off-white powders under normal storage conditions. Tests have shown that these materials do not lump or cake below 100°F (38°C).

### Solubility

Di-Cup® dicumyl peroxide, at practical use concentrations, is soluble in a variety of organic compounds, as shown in Table I. In addition, Di-Cup® is soluble, or disperses readily, in natural and synthetic rubber compounds, silicone gums, and polyester resins. It is soluble in vegetable oils and insoluble in water.

**Table I**
**Solvents for Di-Cup® R Dicumyl Peroxide**

| | Weight % of Di-Cup in a Saturated Solution | |
|---|---|---|
| | At Room Temperature | At Freezing Temperature |
| **Solvent** | 70-80°F (21-27°C) | 25-35°F (-4 to 20°C) |
| **Cyclohexane** | 80 | 70 |
| **Xylene** | 70 | 50 |
| ***alpha*-Methylstyrene** | 70 | 45 |
| ***tert*-Butylbenzene** | 65 | <60 |
| **Isopropyl ether** | 80 | <75 |
| **Dioxane** | 75 | <70 |
| **Amyl alcohol** | <60 | <60 |
| **Diacetone alcohol** | <70 | <60 |
| **Cumene hydroperoxide** | 60 | <50 |
| **Carbon tetrachloride** | <75 | <75 |
| **Trichloroethylene** | <75 | <75 |
| **Dioctyl phthalate** | 55-60 | <10 |



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### Use of Di-Cup® Dicumyl Peroxide

Di-Cup® dicumyl peroxide can be used to crosslink a wide variety of polymers. In developing a new formulation using Di-Cup®, the following basic compounds can be used as a starting point:

| | Parts by Weight |
|---|---|
| **Polymer** | **100** |
| **Filler** | **Variable** |
| **Zinc oxide** | **5.0** |
| **Antioxidant** | **0.5** |
| **Di-Cup® 40KE** | For EPDM, EPM, CSM use **6 – 8 phr**<br>For VMQ, BR use **1.25 to 2.5 phr**<br>For all other elastomers use **2.5 to 5.0 phr** |

Typical results using this basic formulation are shown in Table II.

**Table II**
**Basic Formulations and Properties for Typical Rubbers Cured With Di-Cup®**

| | EPM | EPDM | NR | CR | NBR | SBR | EU |
|---|---|---|---|---|---|---|---|
| **Polymer** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| **HAF Black** | 50.0 | 50.0 | 50.0 | 30.0 | 30.0 | 50.0 | 30.0 |
| **Agerite® Resin** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Zinc Oxide** | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| **Di-Cup® 40KE** | 7.2 | 6.8 | 4.5 | 3.5 | 4.5 | 3.5 | 4.5 |
| **Cure time, min** | 30 | 30 | 20 | 10 | 25 | 20 | 15 |
| **Cure temperature, ºF (ºC)** | 330 (166) | 330 (166) | 330 (166) | 330 (166) | 330 (166) | 330 (166) | 330 (166) |
| **Tensile strength, psi (Mpa)** | 1,200 (8.2) | 2,430 (16.7) | 2,700 (18.6) | 2,785 (19.2) | 3,100 (21.3) | 2,810 (19.3) | 3,240 (22.3) |
| **100% modulus, psi (Mpa)** | 150 (1.0) | 380 (2.6) | 460 (3.1) | 380 (2.6) | 335 (2.3) | 1050 (7.2) | 860 (5.9) |
| **200% modulus, psi (Mpa)** | 320 (2.2) | 1430 (9.8) | 1525 (10.5) | --- | 1120 (7.7) | --- | 2675 (18.4) |
| **Elongation, %** | 500 | 280 | 275 | 190 | 345 | 185 | 230 |
| **Shore A hardness, points** | 53 | 68 | 60 | 71 | 62 | 73 | 70 |

### Cure Time and Temperature

Di-Cup® dicumyl peroxide decomposes when heated to form alkoxy radicals that, in turn, abstract hydrogen from the polymer backbone, forming polymer radicals. A combination of two polymer radicals results in a crosslink. In general, the cure rate (or rate of crosslinking) is equivalent to the rate of Di-Cup® peroxide thermal decomposition. The rate of Di-Cup® cure, therefore, is dependent primarily on cure temperature and is predictable for each polymer system. Care should be exercised to differentiate between rate of cure and state of cure. In a given polymer, rate of cure with Di-Cup® is affected primarily by temperature, while state of cure is influenced by the level of Di-Cup® and other factors.



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The major factor affecting the rate of peroxide decomposition and, therefore, cure rate, is temperature. However, the polymer or medium in which the peroxide decomposes does have some effect on rate of peroxide decomposition. Di-Cup® dicumyl peroxide is much less sensitive to its environment than many other peroxides but still requires some modification of the cure time and temperature for each polymer system. Selection of the proper cure time, for a vulcanizate based on Di-Cup®, depends on performance requirements of that vulcanizate.

Figure 1 is a plot of the crosslinking half-life of Di-Cup® dicumyl peroxide in various systems. In addition to the polymers shown, cis-polybutadiene (BR) has a half-life curve between those of nitrile rubber (NBR) and ethylene-propylene terpolymer (EPDM). Polyisoprene (IR), natural rubber (NR), and styrene-butadiene rubber (SBR) have approximately the same half-life curves, and this common curve lies between those of NBR and the solution.

Under commercial curing conditions, the stock temperature and peroxide decomposition rate are influenced by mold heat-up time, vulcanizate thickness and shape, and other practical factors. Therefore, optimum factory cure conditions require experimentation. This is best accomplished by test-curing the compounds in production equipment for the cure times calculated from the half-lives shown in Figure I. Resulting vulcanizates then are tested for either physical properties such as modulus and elongation, or unreacted peroxide. Plotting any of these against cure time will result in a curve from which cure time to reach the desired state can be read. Cure conditions developed in this manner will assure optimum performance with the peroxide-cured vulcanizate. A laboratory evaluation will optimize laboratory procedure, but will serve only as a guide to production practice.

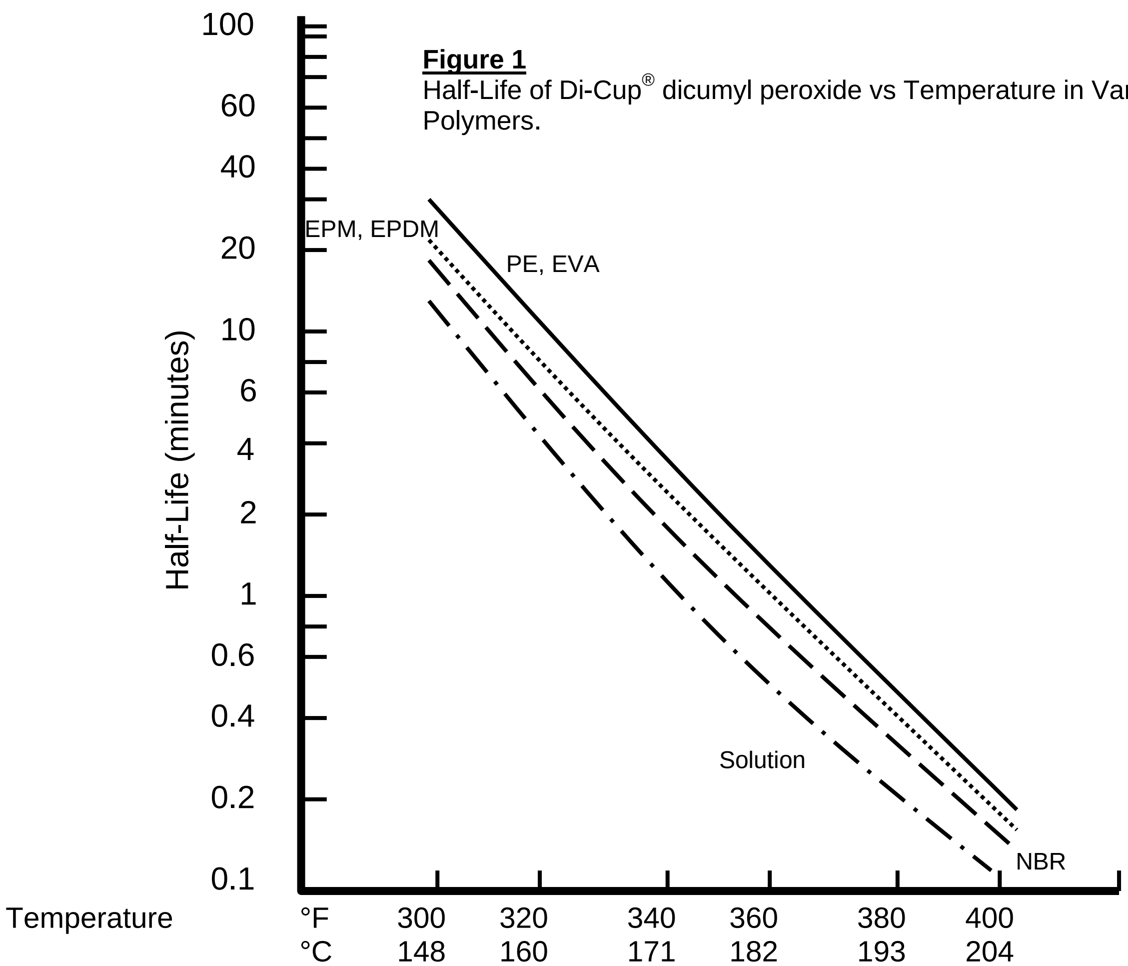


**Figure 1**
Half-Life of Di-Cup® dicumyl peroxide vs Temperature in Various Polymers.



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## Odor of Cured Stocks

Nearly all compounds that have been freshly cured with Di-Cup® dicumyl peroxide have an odor, caused by acetophenone, a normal byproduct of dicumyl peroxide decomposition. The odor is not unpleasant, but is different from the odor associated with other methods of vulcanization. There is no known way to prevent formation of acetophenone. If odor-free stocks are required, either heat treatment or masking can be employed.

## Procedure for Emulsifying Di-Cup® Dicumyl Peroxide

For applications involving aqueous systems (e.g., curing latexes), the following procedure is satisfactory for emulsifying Di-Cup® dicumyl peroxide in the laboratory.

| Component | Parts by Weight |
|---|---|
| Di-Cup® R | 100 |
| Toluene | 35 |
| Oleic acid | 5.6 |
| Water | 101 |
| 30% KOH solution | 2.62 |

Melt the Di-Cup® dicumyl peroxide in a suitable container in a warm-water bath (40°C to 50°C). Add the toluene, mix, then add the oleic acid. Pour this solution into a glass Waring® blender containing the water (warmed to 40° C to 50°C) and the potassium hydroxide solution. Mix for 2 min. at high speed.

When cooled to room temperature, an emulsion of Di-Cup® dicumyl peroxide prepared in this manner is stable for several weeks. Slight shaking will redisperse any settling. If toluene is objectionable, a less stable emulsion can be prepared by omitting it. However, if toluene is omitted, the emulsion should be used directly following preparation and should not be allowed to cool below 45°C.

**For additional information, or to place an order or sample request, call 1.800.331.7654.**

**Appendix**

BR= polybutadiene rubber
EPM= ethylene-propylene copolymer
EPDM= ethylene-propylene terpolymer
CSM= chlorosulfonated polyethylene
CR= neoprene rubber
EVA= ethylene vinyl acetate
IR= polyisoprene
EU= polyurethane
NBR= nitrile rubber
NR= natural rubber

User should also obtain and review Bulletins ORC-202-Safety Aspects of Storing and Handling 55-Gallon Shipping Containers; ORC-203-Summary of Hazard Tests; and ORC-204-Summary of Toxicological Investigations.



**Before handling this material, read and understand the MSDS (Material Safety Data Sheet) for additional information on personal protective equipment and for safety, health and environmental information. For environmental, safety and toxicological information, contact our Customer Service Department at 1.800.331.7654 to request a Material Safety Data Sheet or visit our website at www.arkemainc.com/crosslinking.**



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