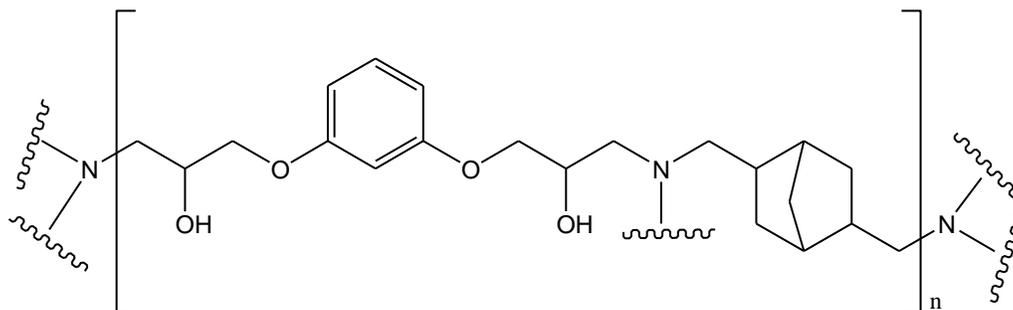


## Elara Polymer Structure



**CAS Number:** 2176443-64-2

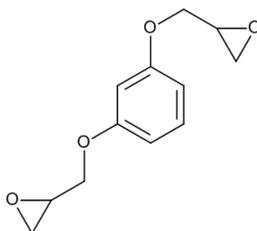
**Chemical Name:** Bicyclo[2.2.1]heptanedimethanamine, polymer with 2,2'-[1,3-phenylenebis(oxy)methylene]]bis[oxirane]

**INCI Name:** Norbornanediamine/Resorcinol Diglycidyl Ether Crosspolymer

## Monomers

### Resorcinol diglycidyl ether

RDGE is an aromatic diepoxyl produced by the reaction of epichlorohydrin with resorcinol.

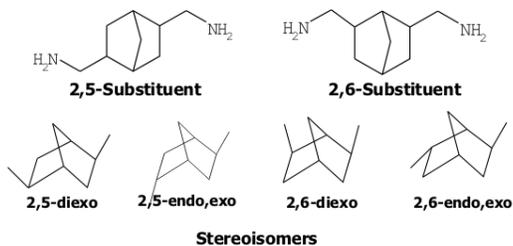


**CAS Number:** 101-90-6

**Chemical Name:** 2-[[3-(oxiran-2-ylmethoxy)phenoxy]methyl]oxirane

### Norbornanediamine

NBDA, norbornanediamine, is a cycloaliphatic diamine. NBDA is a mixture of 2,5- and 2,6-disubstituents, that has four stereoisomers. At ambient temperatures, NBDA is colorless and transparent low-viscosity liquid having no odor or a slight characteristic odor.



**CAS Number:** 56602-77-8

**Chemical Name:** Bicyclo[2.2.1]heptanebis (methylamine)

## Elara Polymerization

Elara polymer is prepared using a dispersion polymerization technique. Liquid RDGE is suspended in water and cosmetic dyes are thoroughly dissolved in the organic phase. The organic phase is agitated with enough shear force to suspend the liquid into 2-3  $\mu\text{m}$  droplets, and the co-reactant norbornanediamine is fed into the polymerization. After the initial exotherm, the reaction is heated to 90-95° C for 1 hour to fully polymerize the product. The suspension is cooled, filtered and dried in a vacuum tumble dryer. The product is then milled to the desired particle size and packaged.



## Elara Molecular Weight Determination

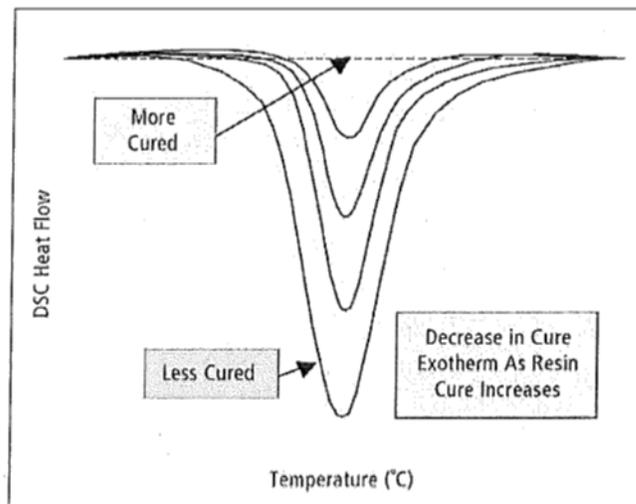
Elara polymer is highly crosslinked, and very insoluble in common GPC solvents. However, differential scanning calorimetry (DSC) can be used to establish the degree of cure or conversion achieved by an epoxy polymer relying on the residual heat of cure.

The residual heat of cure is used to determine the degree of cure and from that, we can infer the percent reaction conversion. Completion of cure is based upon the occurrence of a residual curing exothermic peak. If no peak is observed, then the resin system is completely cured or crosslinked. The DSC curves show how the cure exothermic peak of an Elara polymer becomes smaller as the degree of cure increases. At high levels of cure, the exothermic peak can no longer be detected.

The heat of cure measured of the Elara polymer can be used to assess the percent cure and by inference, the extent of reaction. The following simple equation provides the information.

$$\% \text{ Cure} = [\Delta H_{\text{uncured}} - \Delta H_{\text{sample}}] / [\Delta H_{\text{uncured}}] * 100$$

We combined the two Elara starting monomers in the correct proportions to provide a balanced stoichiometry between amine groups and the available epoxy groups. We then measured the  $\Delta H_{\text{uncured}}$  value. It was then a simple task to measure some of the finished polymer, exposing the samples to a temperature ramp to 140 °C and determining the  $\Delta H_{\text{sample}}$  value. The method indicates the Elara polymer is 98.40% cured or 98.40% converted. The value can be used in the well-known Carothers equations that



relates weight average molecular weight ( $M_w$ ) to degree of polymerization ( $DP_w$ ).  $DP_w = (1+p)/(1-p)$ , where  $p = \% \text{ conversion}$

In this case the:

Repeat unit is  $222 + 154 = 376$

$n = 127$

$M_n = 127 * 376 = 4.78 \times 10^4$  Daltons

This approximation ignores crosslinking, which will dramatically increase the molecular weight. The actual molecular weight if it could be measured, is far higher.

### Characterization of Molecular Weight below 500 & 1000 $M_w$

Due to the insoluble nature of the polymer traditional GPC techniques are not applicable. To determine the low molecular weight fractions it was necessary to Soxhlet extract the polymer with 100 mls of refluxing chloroform for 4 hrs.

Tare weight of thimble	3.0516g
Tare weight of thimble and polymer	8.1070g
Weight after extraction	8.0418g
Weight % extracted oligomers	1.29%

Calculation:  $100 - [(4.9902g/5.0554g) * 100]$

The extract was then characterized by GPC to determine the % below 1000 and 500  $M_w$ .

$M_w$  below 500 =  $1.29 * 0.554\% = 0.71\%$

$M_w$  below 1000 =  $1.29 * 0.885\% = 1.14\%$

## Elara Residual Monomers

Concentration of Norbornane diamine determined by GC < 13 ppm.

Resorcinol diglycidyl ether was not detected in the low molecular weight Soxhlet extracts by size exclusion chromatography.

## Polymer safety Data

### Skin Irritation, OECD 439

Result

#### SIT Results Using the EpiDerm™ Skin Model

Assay Date	IIVS Test Article Number	Sponsor's Designation	Conc. (w/v)	Mean Viability	Skin Irritation Prediction+
5 December 2018	18AM43	Elara Polymer	Neat	102.5%	Non-Irritant
	Positive Control	SDS	5%	2.73%	Irritant

+ - A test article was predicted to be a skin irritant (GHS Category 1 or 2) if the mean relative viability of the three treated tissues was  $\leq 50\%$

### Eye Irritation, OECD 492

Result

#### Summary Results of the EpiOcular™ Eye Irritation Test

Assay Date	IIVS Test Article Number	Sponsor's Designation	Conc.	Exposure Time	Mean Viability (%)	Ocular Irritation Prediction*	pH
5 December 2018	18AM43	Elara Polymer	Neat	6 hours	100.1	No Category	NA
	Positive Control	Methyl Acetate	Neat	6 hours	18.4	Irritant	NA

NA – Not Applicable

\* - If the test substance-treated tissue viability is  $>60\%$  relative to negative control, the test substance is predicted to not require classification and labelling for eye irritation (GHS No Category). If the test substance-treated tissue viability is  $\leq 60\%$  relative to negative control, the test substance is predicted to be an irritant (does not distinguish between GHS 1 and 2).

### Bacteria Reverse Mutation Assay (Ames Test)

Result

“There was no detectable genotoxic activity (i.e. the test article did not show a 2.5 fold increase in counts over the negative solvent control) associated with 5 concentrations (100,50,10,5,1%) of the organic extract (DMSO) of M18-3587.01(Elara Polymer, INCI name: Norbornanediamine/Resourcinol Diglycidyl Ether Crosspolymer Lot LT-8-21).”

**50 Subject Human Repeat Insult Patch Test for Skin Irritation and Skin Sensitization Evaluation**

Result

“No adverse reactions of any kind were reported during the course of the study”