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Epoxy applications in designing useful models in life

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CONTENTS

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Abstract

The present research deals with the preparation of several models, including learning, arts and others, using the famous epoxy resin “Clear Deco Pox 040 for art, décor, and others”. It is eco-friendly and renewable. Epoxy resin was prepared by mixing glycerine, epichlorohydrin, and hydrochloric acid as a catalyst. The resulting models include coatings of the chemical periodic table, besides medals, snail shells, valves of mussels, and both insect and scorpion models. The present products of epoxy resin are characterized by highly transparent, clear, and solid pieces like crystals. The present work recommended using the present epoxy resin in the preparation of learning models in the future, where it is eco-friendly, renewable, and has excellent coating, hardness, and adhesive properties.

Key Words: Epichlorohydrin, glycerol, Hardeners, models.

Introduction:

Epoxy is a polymer known as polyepoxide that contains an epoxide group, and its functional group called epoxy (May 2018). Resin material is a type of plastic liquid that solidifies after adding a hardener (Al Saadi et al. 2023). Synthesis of eco-friendly and renewable epoxy resins is capable of substituting hazardous epoxy resins derived from petroleum (Kocaman et al. 2024). Epoxy resins coat metals and have good mechanical properties, besides high thermal and chemical resistance (Rodríguez-Uicab et al. 2020), as well as being used in electronics, computer chips, LEDs, high electrical insulators, paint brushes, fibre-reinforced plastics, and structural adhesives (Miturska et al. 2021).

Epoxy resins are a highly versatile class of multifunctional reactive intermediates that are cross-linked into three-dimensional networks with curing agents or "**hardeners**" as multifunctional amines, carboxylic acid anhydrides, and phenolic resins. When cured, the resulting thermoset materials formed without the generation of volatile by-products. This results in void-free cured parts, which is particularly important in thick structures. Thereby, the present research deals with the preparation of several models using epoxy resins, is a safe paint, instead of epoxy resins derived from petroleum.

2. The Theoretical Framework:

The yellowing of epoxy resins is common and causes problems in art and decor applications. Scientists attributed it to aging of them or from exposure to high intensive light (**Down, 1986**).

Epoxy is highly water resistant and hardens underwater. Therefore, it is used as an adhesive in the construction of aircraft, cars, bicycles, boats, golf clubs, snowboards, and adhesives for wood, metal, glass, stone, and plastic. It can be flexible, rigid, transparent, opaque, or coloured. It is resistant to heat and chemicals. Its adhesive weakens at 177°C. Some types of it harden after exposure to ultraviolet light and thus used in optics (**Morena, 1988**).

Epoxy coatings developed for use on metal surfaces as car paint, but its paints tend to crack due to exposure to UV rays (**Bayliss** and **Deacon, 2002**).

Liquid epoxy resins are irritants to human eyes, skin, and the respiratory system (**Holness and Nethercott, 1989**), and thus solid epoxy resins are safer than liquid (**Tavakoli, 2003**).

The applications of epoxy include coating and adhesives (**Schulenburg** and **Kramer 2004**).

Epoxies have excellent adhesion, chemical and heat resistance, excellent mechanical properties, and very good electrical insulating properties, and many properties of them modified, as silver-filled epoxies with good electrical conductivity, in spite of being electrically insulating. Moreover, there are types of them that offer high thermal insulation and thermal conductivity, besides their high electrical resistance for electronics applications (**May 2005**).

Commercial epoxy monomers produced by the reaction of hydroxyl compounds with epichlorohydrin, where the hydroxyl group derives from aliphatic di- or tri-alcohols, such as glycerol,

beside the nitrogen atom of an amine or amide that can react with epichlorohydrin (**Pham** *et al*., **2005**).

Epoxy resins mixed with other materials to achieve the desired properties or reduce costs, but the resulting mixture is exothermic, and thus, it recommended mixing small quantities to avoid waste and ensure safety. Moreover, there are ways to strengthen brittle epoxy resins, as rubber toughening (**Thomas** *et al*., **2005** and **Unnikrishnan** and **Thachil**, 2006).

Epoxy coatings used in the painting of drinking water pipes to protect steel pipes from rust (**Monetta** *et al*., **1993**; **Cui** *et al*., **2020**).

When epoxy and hardener materials are mixed, the result is a highly transparent, clear, and solid piece like crystal, which we can use in various types of arts such as wood tables, making accessories, distributions, and ornaments, making models, and many unlimited artistic ideas (**Thomas** *et al*. **2020**).

Some types of Epoxies acts as coatings for home electric appliances to protect steel pipes of oil, gas, and drinking water from rust and improve the adhesion of car paints, food cans, and decorating floors. Moreover, their application applied in the production of molds, models, sheets, assemblies, and reinforced parts to replace metals and wood at a lower cost and time (**Morgiante** *et al*., **2022**).

Epoxy compounds have higher thermal conductivity for heat dissipation (**Mazumder** *et al*. **2023**).

A new bio-based epoxy resin synthesized by reacting bio-citric acid ester with epichlorohydrin (**Kocaman** *et al*., **2024**b).

The synthesis of eco-friendly and renewable epoxy resins is of great importance instead of hazardous petroleum-derived epoxy resins (**Kocaman** and **Akyay**, **2024**).

Epoxy resins are usually brittle, and their hardness, durability, and heat resistance increased by using hydroxide-terminated polyester, aryl ether or ketone as a reinforcing agent (**Li** *et al*., **2024**).

Concerning epoxy applications in industry, epoxy resin (051) commonly used due to its robust strength and high modulus. Epoxy resin commonly used due to its high strength and high modulus of elasticity, but the resinous brittleness limits its use in many applications (**Zhang** *et al*. **2024**).

The development of new epoxy gave rise to high fracture toughness at low temperatures (**Studer** *et al*. **2024**).

Epoxy resins are widely involved in the field of coatings because of their excellent mechanical performance, superior chemical durability, and good adhesion to the substrate (**Chen** *et al*. **2025**).

Tannic acid-based material can resist the corrosion of epoxy coatings (**Mao** *et al*., **2025**).

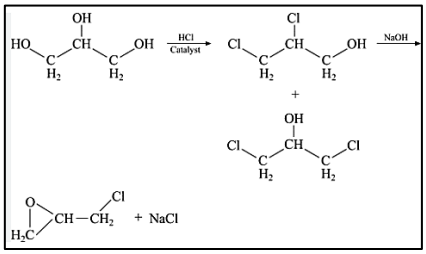
Water and oxygen are two major media for the corrosion of metals, so oxygen-consuming coatings developed as an effective way to improve the corrosion resistance of coatings. Corrosion tests have shown that complex PFA/epoxy coatings had superior corrosion resistance (**Song** and **Wang**, **2025**).

The current 5G era has increased the challenges of decreasing heat in electronic devices, and the development of new thermally conductive materials has become critical. A bio-based thermally conductive polymer had synthesized from soybean oil, epoxy, gallic acid and boron nitride (**Wang** *et al*., **2025**).

3. Methods of Research and the tools used:

Chemical Equations:

In the present research, ready-made epoxy resin "Clear Deco Pox 040" are been directly used, as in the figure.



The epoxy mixing with a hardener (typically an amine compound in commercial products like Clear Deco Pox 040), the following cross-linking reaction occurs:

Epoxy group (-CH(O)CH₂-) + H₂N-R (amine hardener) → -CH(OH)CH₂-NH-R (cross-linked network)

The equipment's:

Silicone mold (custom-made or store-bought in a periodic table shape).

Mixing cups and stir sticks.

Protective gloves and mask.

Small printed element labels (if embedding).

Heat gun or torch (to remove bubbles).

We measured 100 grams of resin.

We added 30 grams of hardener to the resin.

Epoxy Resin Preparation Procedure:

1-Mixing Process: We mixed the solution thoroughly in one direction for 7 minutes to ensure proper blending.

2-Resting Time: We let the mixture settle for 10 minutes to allow air bubbles to escape.

3- Pouring into Molds: We carefully poured the mixture into the prepared molds.

We applied this preparation method for all the samples.

While working on the practical experiment, we observed oxidation when fresh, live flowers were placed in the resin, causing a change in the flower's colour. However, when using dried flowers, they retained their original colour, and no oxidation observing.

We prepared the resin following the previously mentioned method. We then poured the first layer of resin and allowed it to cure for 24 to 48 hours. Once it had fully cured, we adhered the printed element symbols onto the surface. After ensuring proper adhesion, we poured the second layer of resin over the elements and let it cure for another 24 to 48 hours, similar to the first layer.

Resin was used to preserve insects and small animals, as we did with the scorpion and the "Um 44"animals.

We poured a layer of resin into the mold and let it dry for 48 hours. Then, we placed the scorpion and the "Um 44" animal on top of the first resin layer inside the mold. After that, we poured another layer of resin, fully immersing the animals. We left it to dry for another 48 hours.

Finally, we removed them from the mold, successfully preserving the scorpion and the "Um 44". This cross-linking creates the hard, transparent, and durable material observed in this present final product.

4- **Cooling and hardening**: After the reaction is complete, allow the mixture to cool.

5- **Storage**: Store the resulting epoxy resin in tightly sealed containers away from light and heat.

6- Pouring into Molds:

We carefully poured the mixture into the prepared molds for all samples.

The other preparation that is been applied in the present research:

1--Chemical reaction:

Mix, 100 ml of glycerine and 50gm of epichlorohydrin "epoxy resin" in a glass container, then add 2 ml of hydrochloric acid as a catalyst.

2-Heat the mixture in temperature not exceeding 60°C, adjusted by thermometer with continuous stirring .

3. Cooling and Curing
- After the reaction is complete, allow the mixture to cool.
- Additional substances such as dyes or additives can be introduced to enhance properties.

4. Storage
- Store the resulting resin in airtight containers, away from light and heat.

3-Epoxy Resin Synthesis and Chemical Equations

The synthesis of epoxy resin involves a two-step reaction process:

1-Formation of chlorohydrin intermediates Glycerol reacts with epichlorohydrin in the presence of HCl as an acid catalyst:

$C_3H_8O_3$ (glycerol) + C_3H_5ClO (epichlorohydrin) → $H[OCH_2CH(OH)CH_2OCH_2CH(CH_2Cl)O]_nH$ (chlorohydrin intermediates)

2-Dehydrochlorination to form epoxy groups The chlorohydrin intermediates then undergo dehydrochlorination

$H[OCH_2CH(OH)CH_2OCH_2CH(CH_2Cl)O]_nH$ → $H[OCH_2CH(OH)CH_2OCH_2CH(O)CH_2]_nH$ + HCl

This is the final epoxy prepolymer containing the reactive epoxide groups that may be added to different dyes to enhance their properties.

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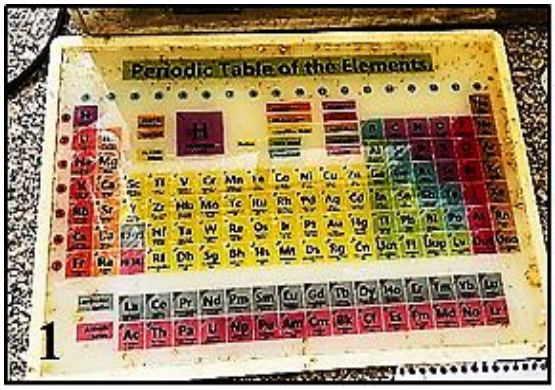
4. Results of Research:

The present results reveal several successful models after coating the famous eco-friendly and renewable epoxy resin, including a coated chemical periodic table, snail shells, insect models, medals, and valves of mussels filled with the names of the present two supervisors. The result-coated products of epoxy resin characterized by highly transparent, clear and solid piece like crystal, as in the coated models in the figures (1-8) [chemical periodic table (Fig. 1), insects "butterflies" (Figs. 2&3), mussel's valves (Fig. 4) filled with names of the two present supervisors (Fig. 5), models as medals (Fig. 6), two artistic shapes (Fig. 7) and *Scorpion* (Fig. 8)].


Periodic Table of the Elements
1


5

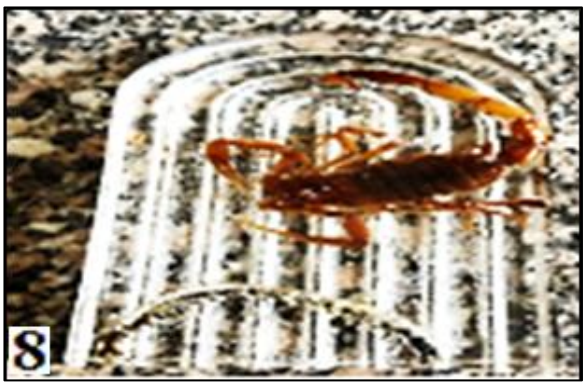

2


6


3


7


4


8

5. Interpretation of Results

Epoxy resins are good materials for coating metals (Rodríguez-Uicab *et al*. 2020). The present results reinforced this report. They were produced by the reaction of the hydroxyl compound with epichlorohydrin, where the hydroxyl group derives from aliphatic tri-alcohols, as glycerol, that can react with epichlorohydrin (Pham *et al*., 2005), as in the present work. Epoxies have excellent adhesion (May 2005), as in the present models. Epoxies are able to use as coatings of home electric appliances and to protect steel pipes of oil, gas, and drinking water from rust and improve the adhesion of car paints, food cans, and decorative floors. Moreover, they used in the production of models (Morgiante *et al*., 2022), and these results agree with the present results. Epoxy is an adhesive for wood, metal, glass, stone, and plastic. It is flexible, rigid, and transparent (Morena, 1988). Epoxy resins are widely involved in the field of coatings because of good adhesion to the substrate (Chen *et al*. 2025), and this agrees with the present work. When mixing epoxy and hardener materials, the resulting material is a highly transparent, clear, and solid piece like the crystals that are used in making accessories, models, and many unlimited artistic ideas (Thomas *et al*. 2020), as in the present models. Epoxy resin is commonly used due to its high strength and high modulus of elasticity (Zhang *et al*., 2024), as in the present results.

Conclusion:

The present results concern the preparation of several models using the famous eco-friendly and renewable “prepared and ready-made” epoxy resin, including the chemical periodic table, insects (butterflies), mussel's valves “without and filled with names of the two present supervisors, models as medals and two artistic shapes. The resulting models are characterized by a highly transparent, clear, and solid piece-like crystal. The present work recommendes the use of the present epoxy resin in the learning models in the future, where it has excellent coating, hardness, and adhesive properties.

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المستخلص العربي

يتناول هذا البحث تحضير نماذج مختلفة تستخدم كنما ، وذلك باستخدام الراتنج الإيبوكسي الشائع "كلير ديكو ديكوبوكس 040" للفنون والديكور وغيرها، وهو صديق للبيئة وقابل للتجديد، وقد تم تحضير راتنج الإيبوكسي بخلط الإيبيكلوروهيدرين والمصلب، وقد أشتملت النماذج الناتجة طلاءات للجدول الدوري الكيميائي بالإضافة إلى الميداليات وأصداف القواقع ومصاريع أصداف بلح البحر ونماذج الحشرات والعقرب. وتميزت منتجات راتنج الإيبوكسي في هذا البحث بشفافيتها العالية ونقائها وصلابتها وكثيرة الشبه بالبلورات. وقد أوصي هذا البحث باستخدام راتنج الإيبوكسي الحالي في تحضير نماذج تعليمية مختلفة لما يتميز به هذا الراتنج من إنه صديق للبيئة ومتجدد وله خصائص طلائية وصلابة وقوة لصق ممتازة.