

Mühendislik Fakültesi



Kimya Mühendisliği Bölümü

KMB322-Polimer Kimyası ve Teknolojisi

Dr. Öğr. Üyesi, İsa DEĞİRMENCI

Bakalit

KMB322-Polimer Kimyası ve Teknolojisi

Hafta-8



Bakalit (1907)



Leo Bekalend'den önce elde edilen fenol-formaldehit denemeleri olmuştur.

Elde edilen ürün, sert, gözenekli ve ufalanan bir üründür.

Sebebi, tepkime ekzotermik olup çıkan ısı ile yan ürün olarak H_2O 'nun buharlaşmasıdır.

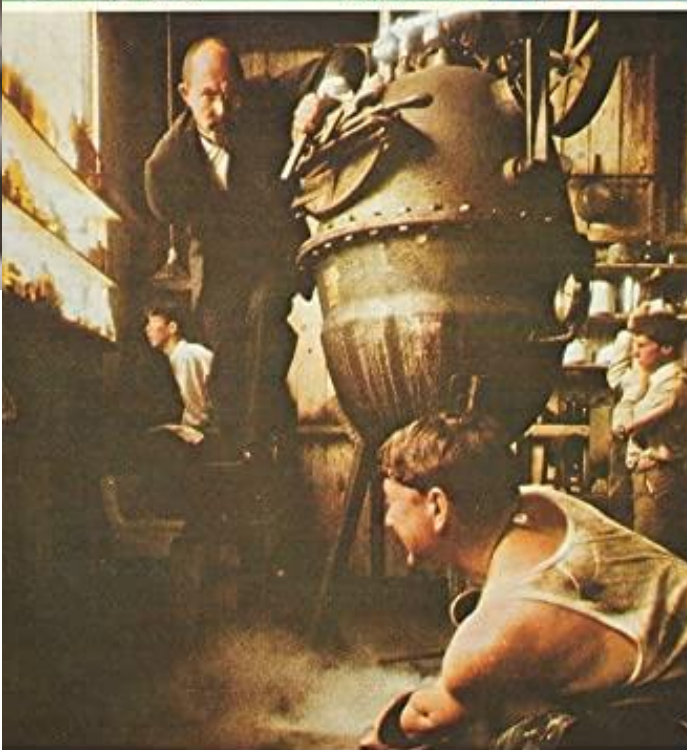




**Leo Baekeland:
"Mr. Plastics"**

1863-1944

THE NATION'S WEALTH



Leo Baekeland: "Mr. Plastics"

1863-1944 *Father of the Plastics Industry*

Perhaps more than any other products, plastics have become symbolic of our modern way of life. Inexpensive and usable in everything from automobile engine parts to imitation flowers, plastics are viewed by some as a tremendous boon to mankind, and by others as a nonbiodegradable environmental hazard.

Although scientists had been working on various aspects of synthetic materials since the early 19th century, the man responsible for developing the U.S. plastics industry was Leo Hendrik Baekeland. Born in Ghent, Belgium, on November 14, 1863, he attended the University of Ghent and received his doctorate in chemistry there in 1884. After teaching for five years, Baekeland won a traveling fellowship and came to America in 1889. Always interested in photography, he had developed a slow-developing photographic paper, called Velox, which he decided to produce and sell himself. Forming his own chemical company in Yonkers, New York, Baekeland made Velox into a very popular product. When he sold his company to Eastman Kodak Company in 1899, the inventor became a millionaire.

Baekeland's interest in chemistry did not wane, however. He continued to work as a consultant for the Hooker

Electro-Chemical Company, concentrating on the problem of regenerating spent electrolytes by adding salts to them. Then, in 1905, he began working on what would become his most famous discovery. By synthesizing carbolic acid with phenol and formaldehyde, he developed a resinous material that was resistant to heat and extremely adaptable to different chemical combinations. A few years later, in 1909, he announced the invention of what he called Bakelite, thus ushering in the age of plastics.

In 1910 Baekeland founded the General Bakelite Company in Perth Amboy, New Jersey, adding new plants as the demand for his products continued to increase. In 1930 he built a new and enlarged factory at Bound Brook, New Jersey, and in 1939, the year he retired from the industry, the company was sold to the Union Carbon and Carbide Corporation. By then the plastics industry had become a giant, producing everything from engine parts and electrical equipment to buttons and toys. It also led to the creation of such other man-made materials as nylon, orlon, and mylar. The man who was responsible for it all, Leo Baekeland, died in Beacon, New York, on February 23, 1944, at the age of 80.

Illustration: A recreated scene of Dr. Baekeland synthesizing Bakelite

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I was trying to make something really hard, but then I thought I should make something really soft instead, that could be molded into different shapes. That was how I came up with the first plastic. I called it Bakelite.

— *Leo Baekeland* —



Kekula'nın öğrencisi (Gent Üniversitesi)

21 yaşında PhD

26 yaşında Doçent

1899 Velox'u üretip Kodak'a
700bin Dolara satar

1907 Bakalit üretilir

1909 Bakalit'in patenti

1910 Bekalite Company

I. Dünya Savaşı'nda uçak
pervanesi yapımı veya pervane
cilasası



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Bakalit sentez aşamaları

Aşama A: Viskoz veya katı, fakat çözücüde çözünebilen reçine

Aşama B: Bir miktar sert çözünmeyen fakat ısı ile şekillendirilebilen reçine

Aşama C: Tamamen kürlenmiş, katı, sert çözücüde çözünmeyen ve ısı ile şekillendirilemeyen Bakalit.



Aşama A + Aşama B



ISI

Aşama C
(Bakalit)



Resoles & Novolacs



Resoles

- Formaldehit > Fenol
- Baz katalizle
- Kızılımsı kahverengi bir hal alıncaya kadar ısıtılır (70-100 °C)
- Bakalit oluşuncaya kadar son ısıtma (120 °C)
- Tek-adımlı reçine olarak adlandırılır.



Novolacs

- Fenol > Formaldehit
- Asit katalizli
- Sert ve kırılğan materyal oluşuncaya kadar ısıtma (Sıcaklık 100°C)
- Kürtleme ajanı ilavesi (diğer katkı maddeleri de)
- Bakalit oluşuncaya kadar ısıtma (Sıcaklık 120°C)
- İki aşamalı reçine diye adlandırılır



Tipik bir Bakalit Sentezi Demonstrasyonu



SUPPLIES

- 25g 37% formaldehyde
- 20g phenol
- 55mL glacial acetic acid
- ~60mL 31.45% hydrochloric acid

Direkt Asit Katalizörü kullanıldığında





NileRed

Asit yavaş yavaş
ilave edilerek
hazırlanan bakalit



NileRed



Resoles

- Formaldehit > Fenol
- Baz katalizle
- Kızılımsı kahverengi bir hal alıncaya kadar ısıtılır (70 °C)
- Bakalit oluşuncaya kadar son ısıtma (120 °C)
- Tek-adımlı reçine olarak adlandırılır.

<https://www.youtube.com/watch?v=phNLecfyWS8>



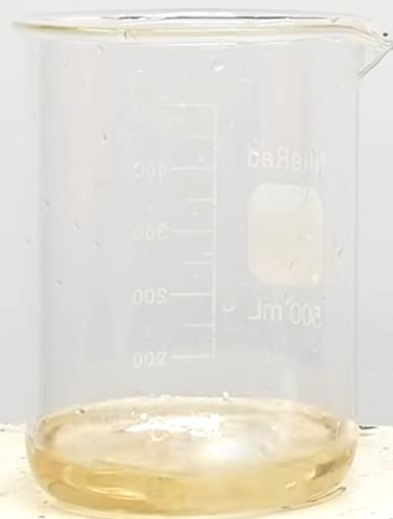
Doçulu



SUPPLIES

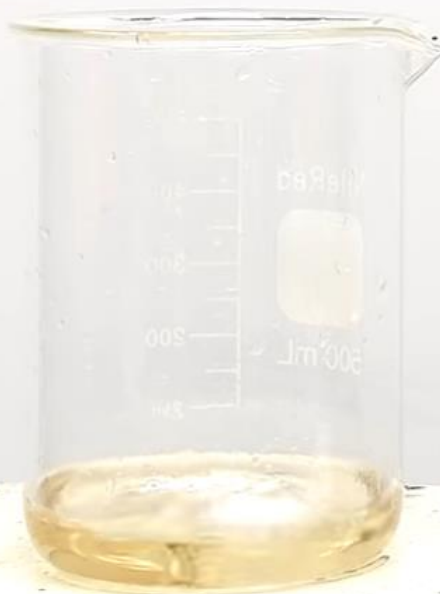
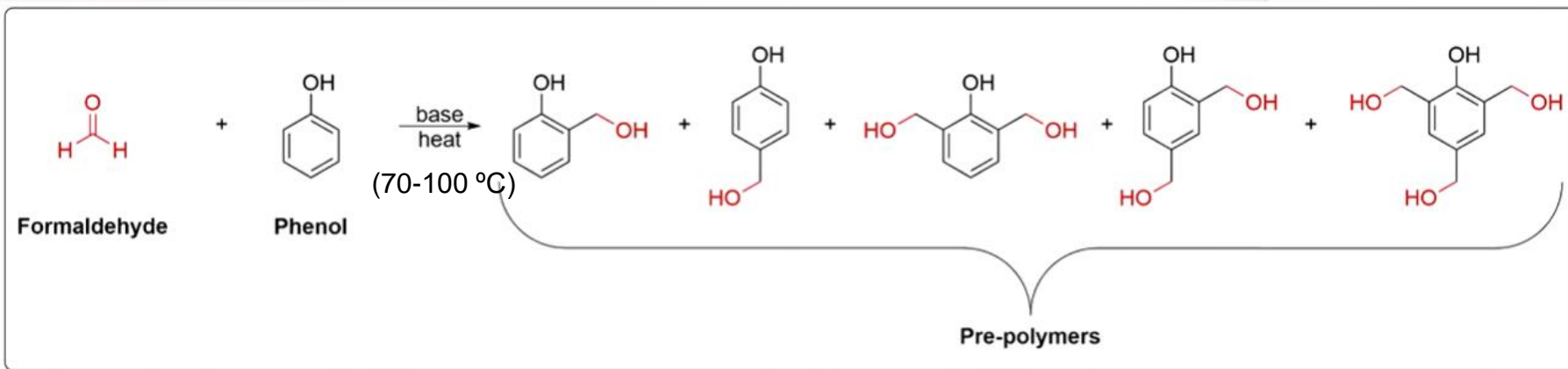
- 25g 37% formaldehyde
- 20g phenol
- Several drops of 10% NaOH

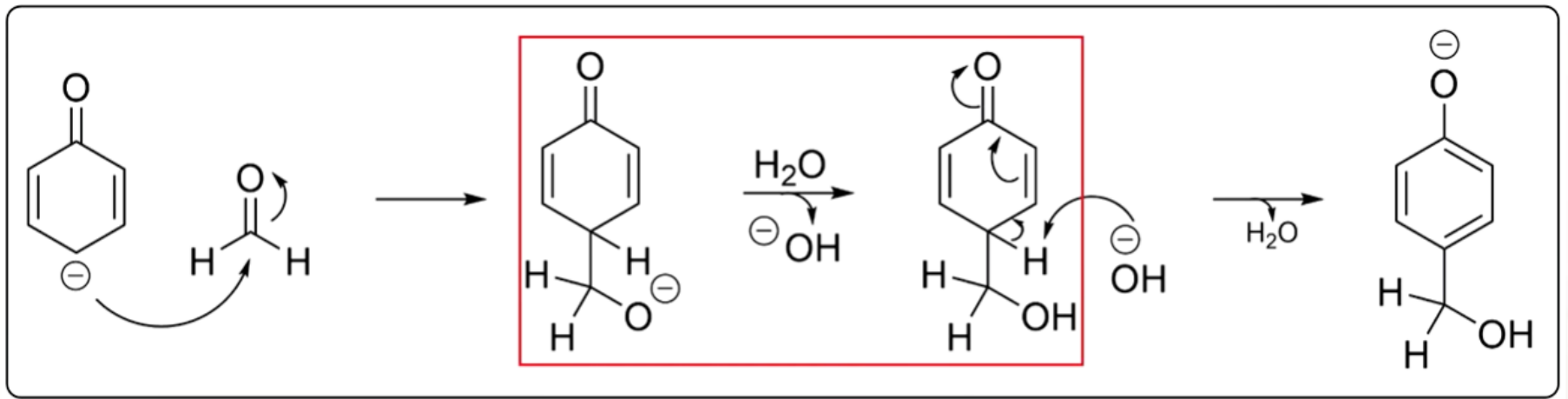
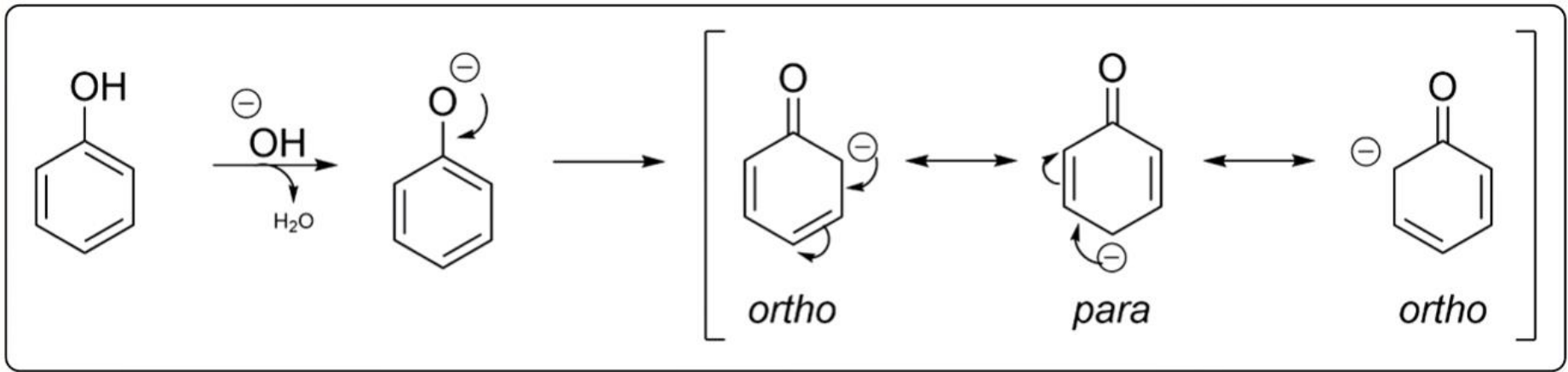
1.5mol formaldehyde per 1 mol phenol



NileRed







Aşama A: Viskoz veya katı, fakat çözücüde çözünebilen reçine

Aşama B: Bir miktar sert çözünmeyen fakat ısı ile şekillendirilebilen reçine

Aşama C: Tamamen kürlenmiş, katı, sert çözücüde çözünmeyen ve ısı ile şekillendirilemeyen Bakalit.

Aşama **A**

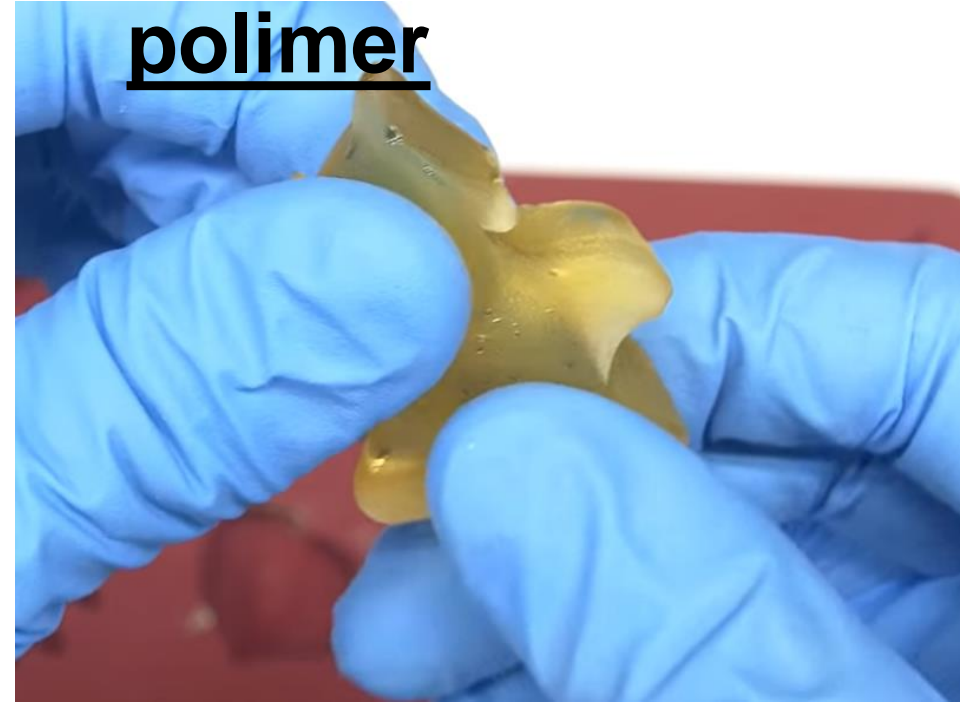




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Aşama B: Pre-polimer

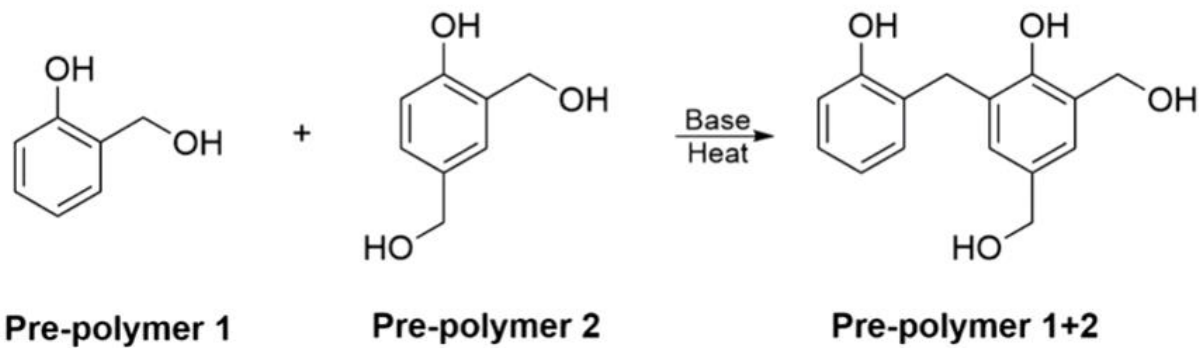


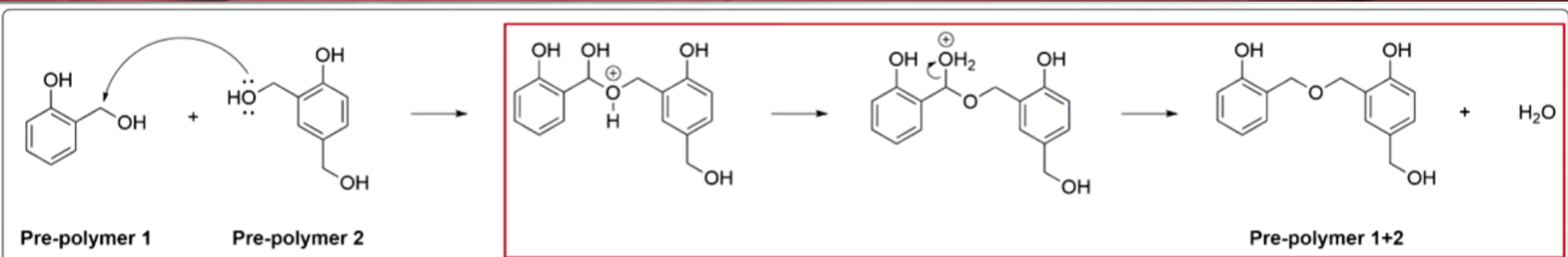
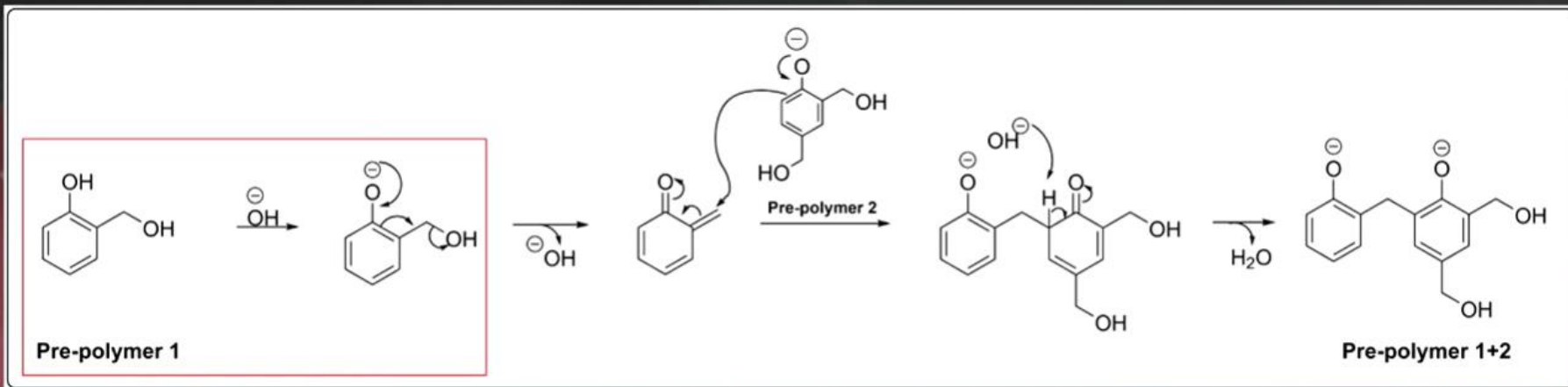
Aşama C: Bakalit

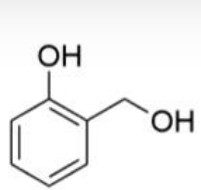


Carbon-carbon bonds
or
Ether groups

(70-100 °C)

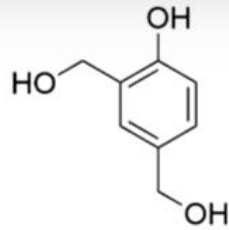






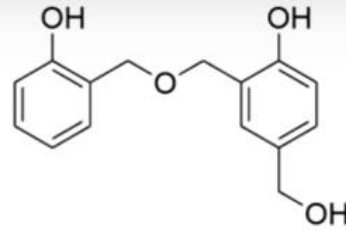
Pre-polymer 1

+

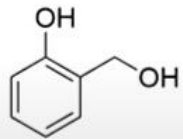


Pre-polymer 2

$\xrightarrow[\text{Heat}]{\text{Base}}$

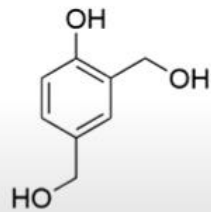


Pre-polymer 1+2



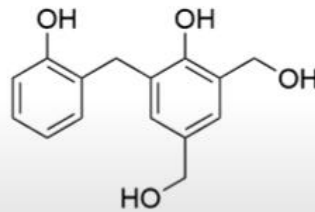
Pre-polymer 1

+



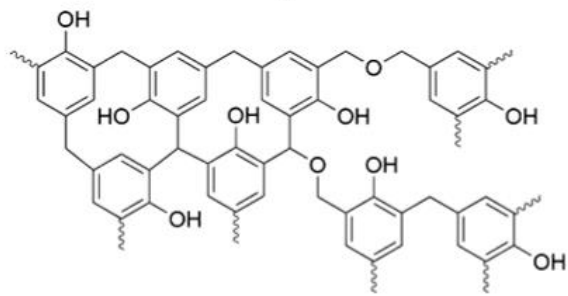
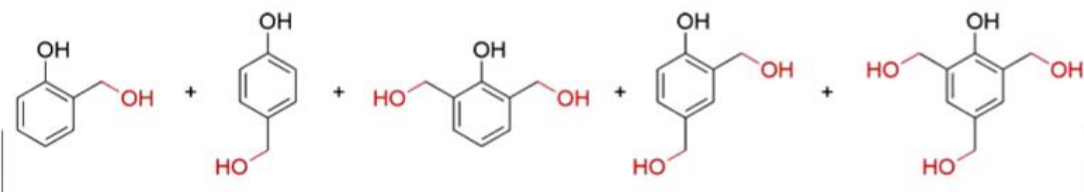
Pre-polymer 2

$\xrightarrow[\text{Heat}]{\text{Base}}$



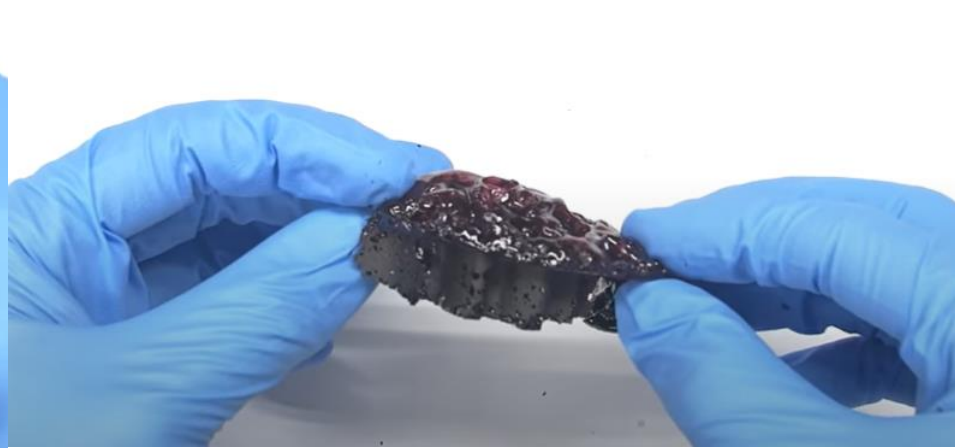
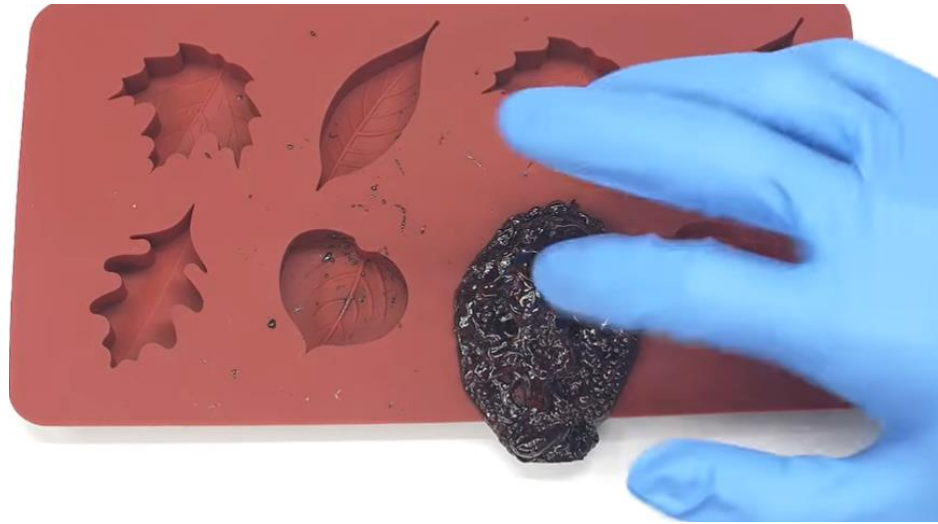
Pre-polymer 1+2





Densely linked polymer network (Bakelite)





Novolacs

- Fenol > Formaldehit
- Asit katalizli
- Sert ve kırılğan materyal oluşuncaya kadar ısıtma (Sıcaklık 100°C)
- Kürtleme ajanı ilavesi (diğer katkı maddeleri de)
- Bakalit oluşuncaya kadar ısıtma (Sıcaklık 120°C)
- İki aşamalı reçine diye adlandırılır

https://www.youtube.com/watch?v=z-l2_WDqW1A

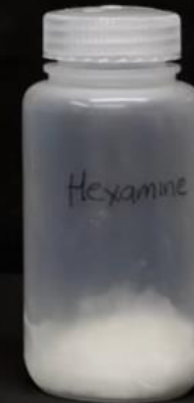


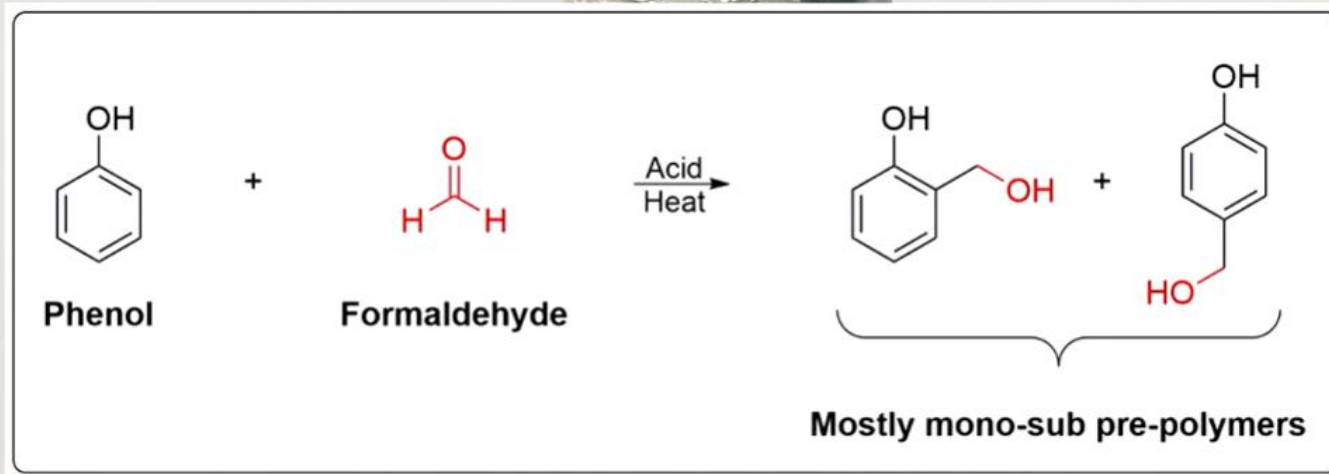
SUPPLIES

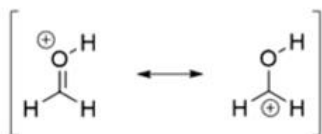


- 14g 37% formaldehyde
- 0.2g sulfuric acid
- 1.2g hexamine

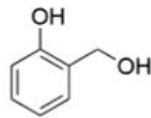
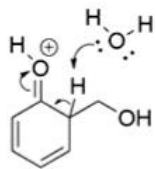
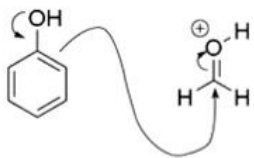
- 19g phenol
- 0.16g sodium hydroxide



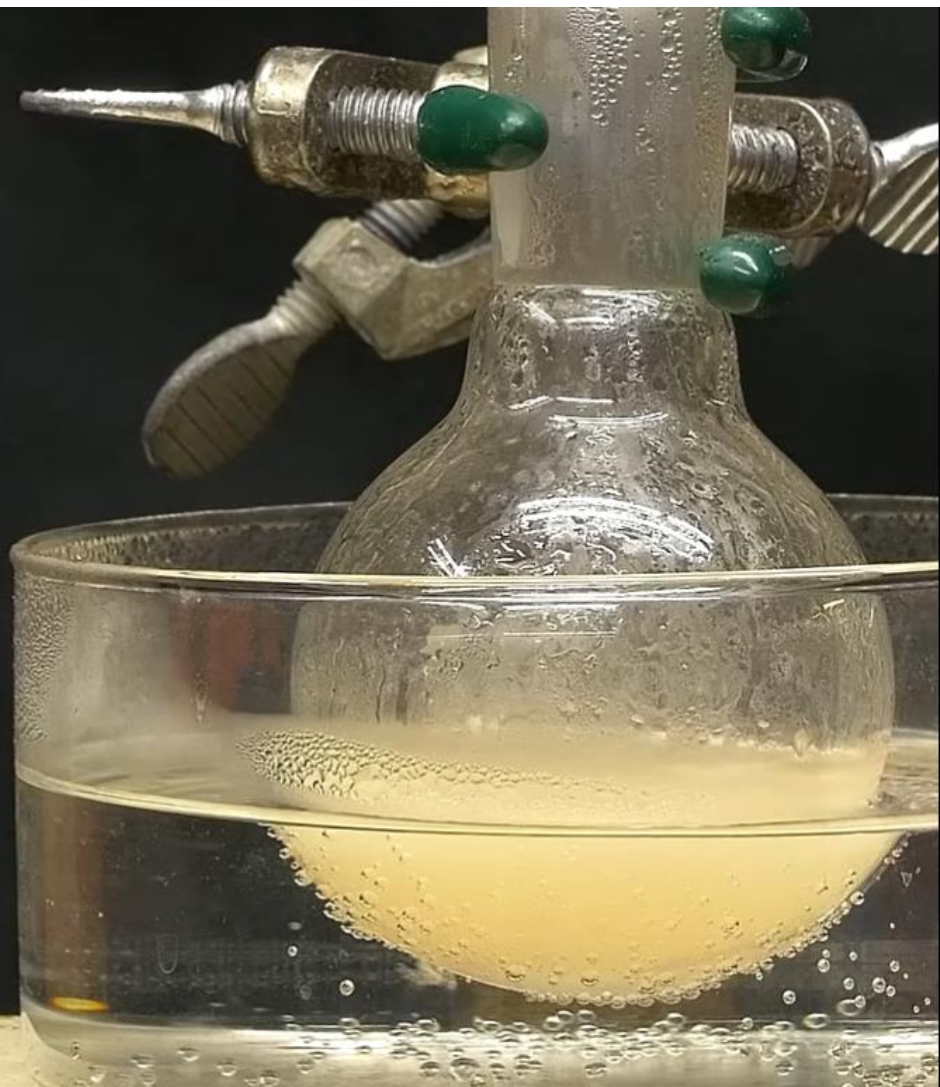




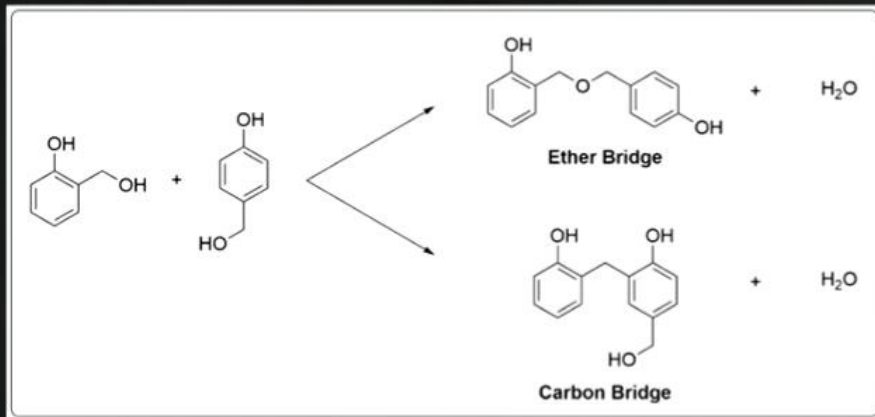
Formaldehyde



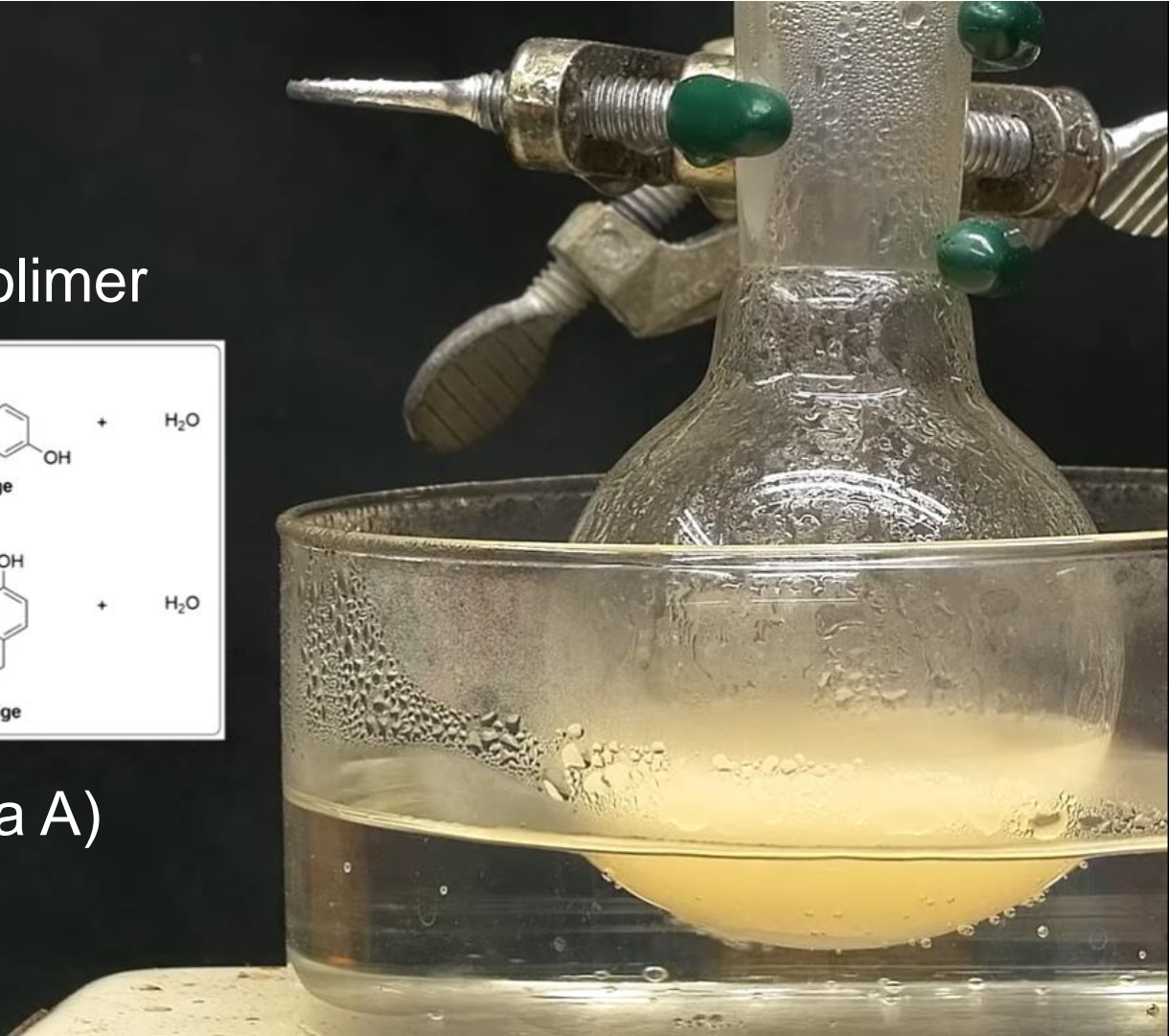
Phenol



Pre-polimer



(Aşama A)



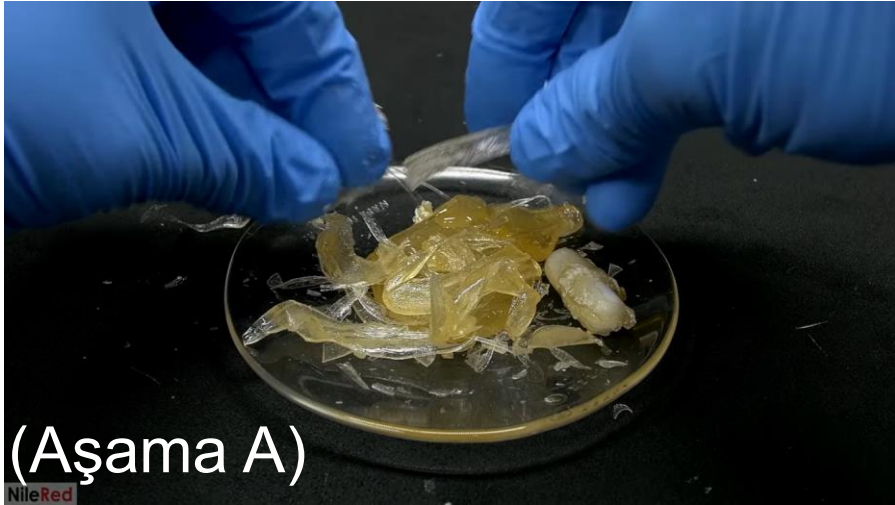
(120 °C Vakum destilasyonu ile suyun uzaklaştırılması)





NileRed



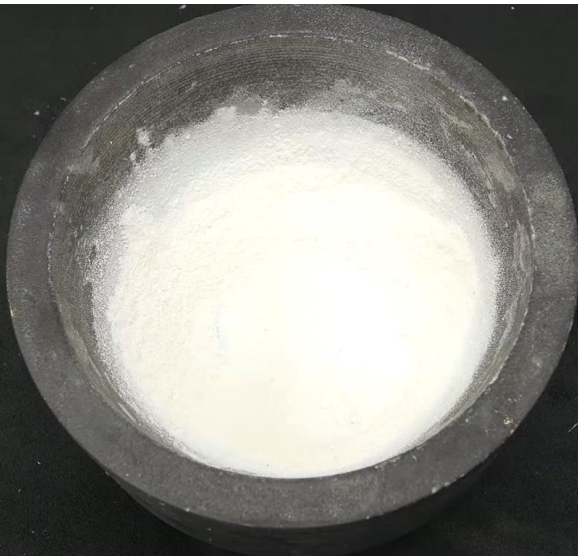


(Aşama A)

NileRed



NileRed



NileRed



(Novalac)





Represents about 9% hexamine by weight
Best performance is apparently between
9-10% for the 1.2:1 phenol:formaldehyde
ratio that I used



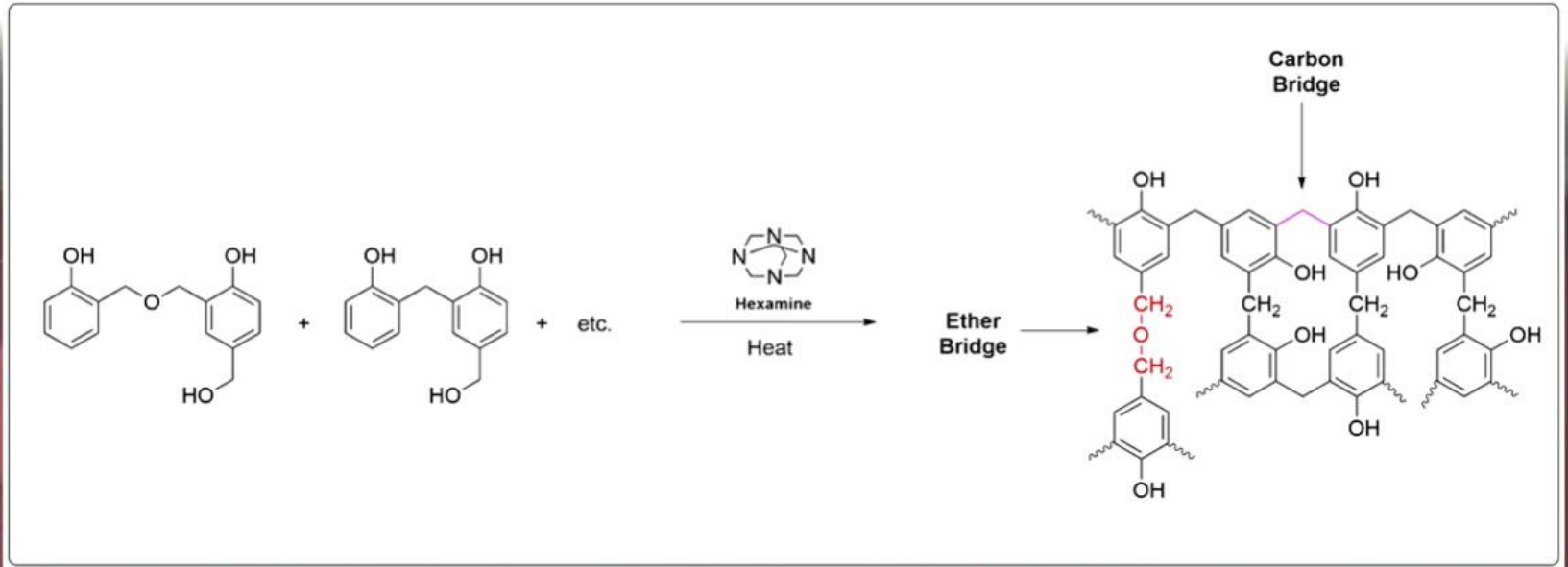
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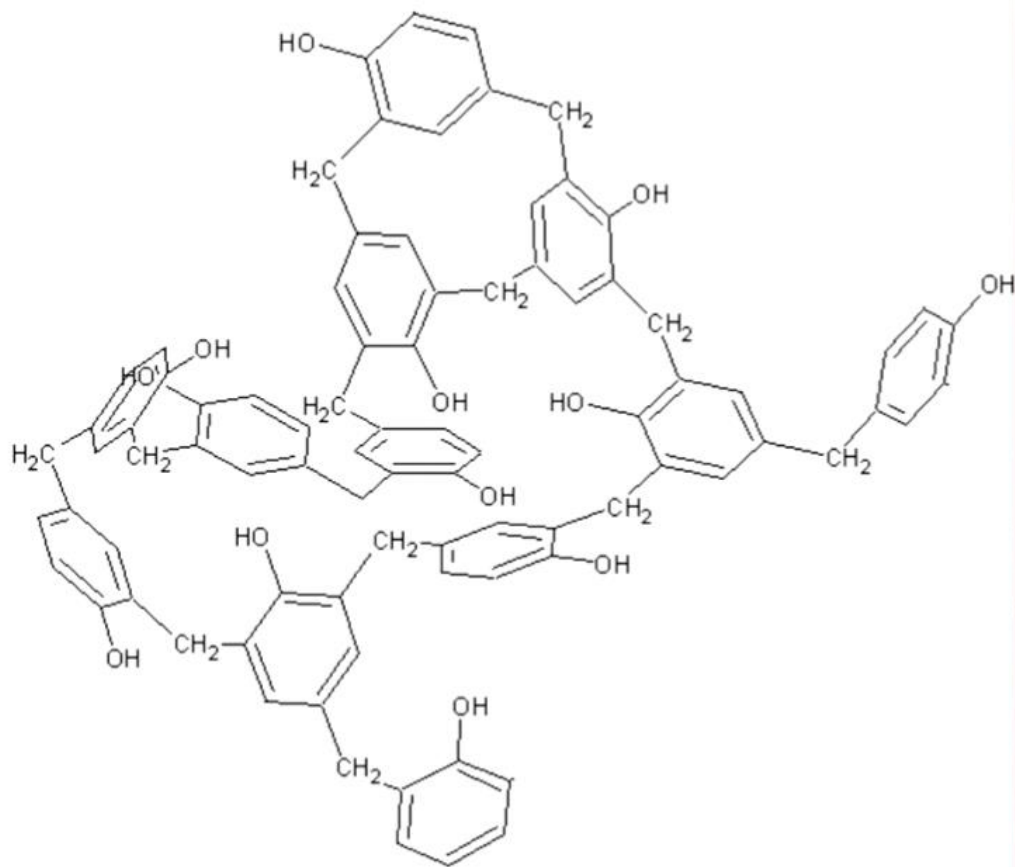




NileRed







3D structure of Bakelite from Wikipedia



(Aşama B)



