Welcome to 3.091

Lecture 29

November 20, 2009

Polymers: Synthesis, Properties, & Applications

3.091 Test #3
"celebration part 3"
Monday, November 23, 2009

coverage:

defects
amorphous solids
kinetics
diffusion
solutions
acids & bases
no orgo
no polymers

Makeup test December 2 during class

$H_2O_2 \rightarrow 2OH\bullet$

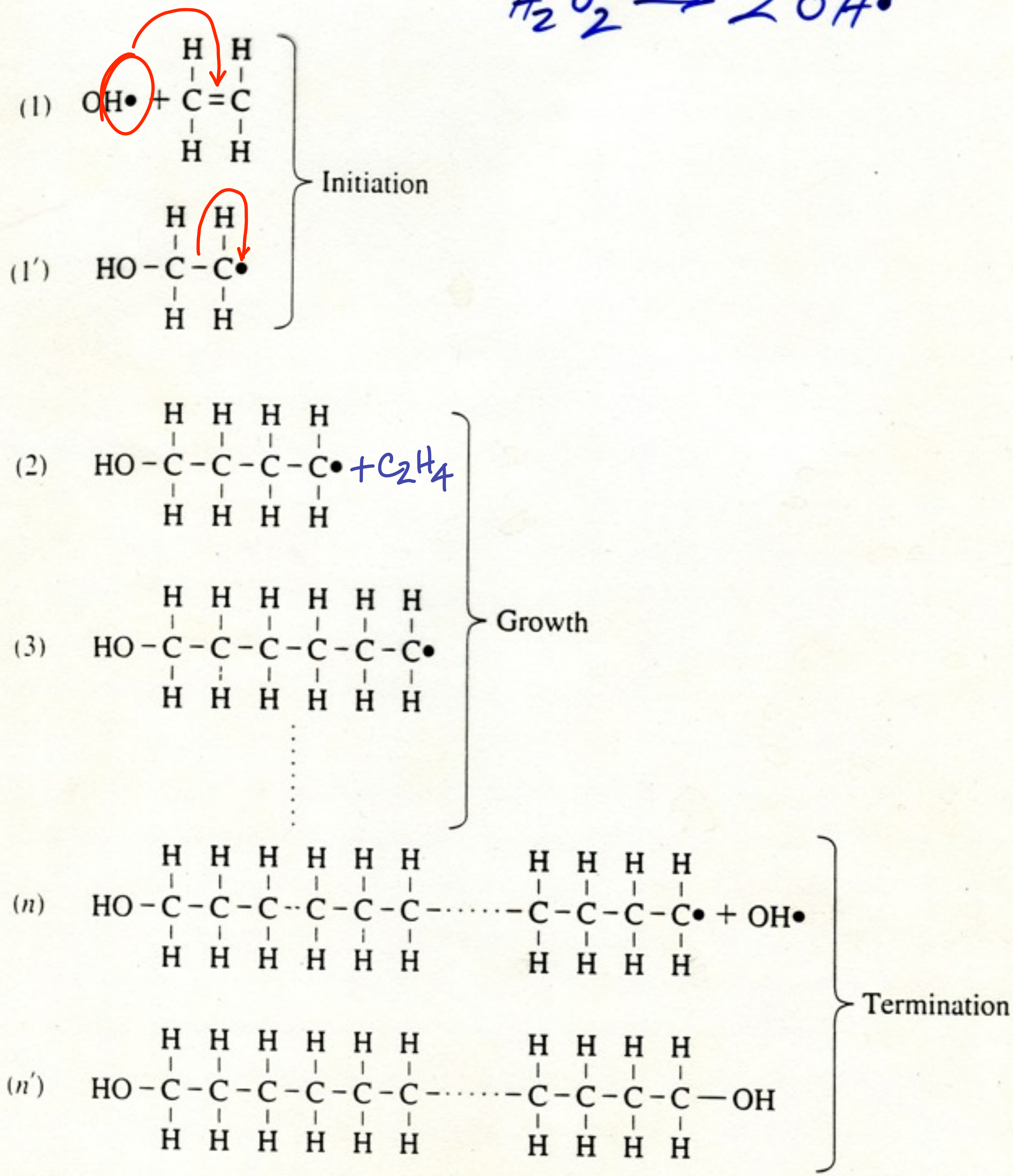
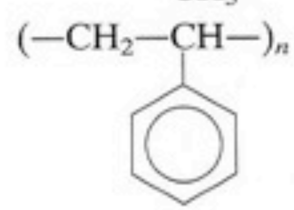
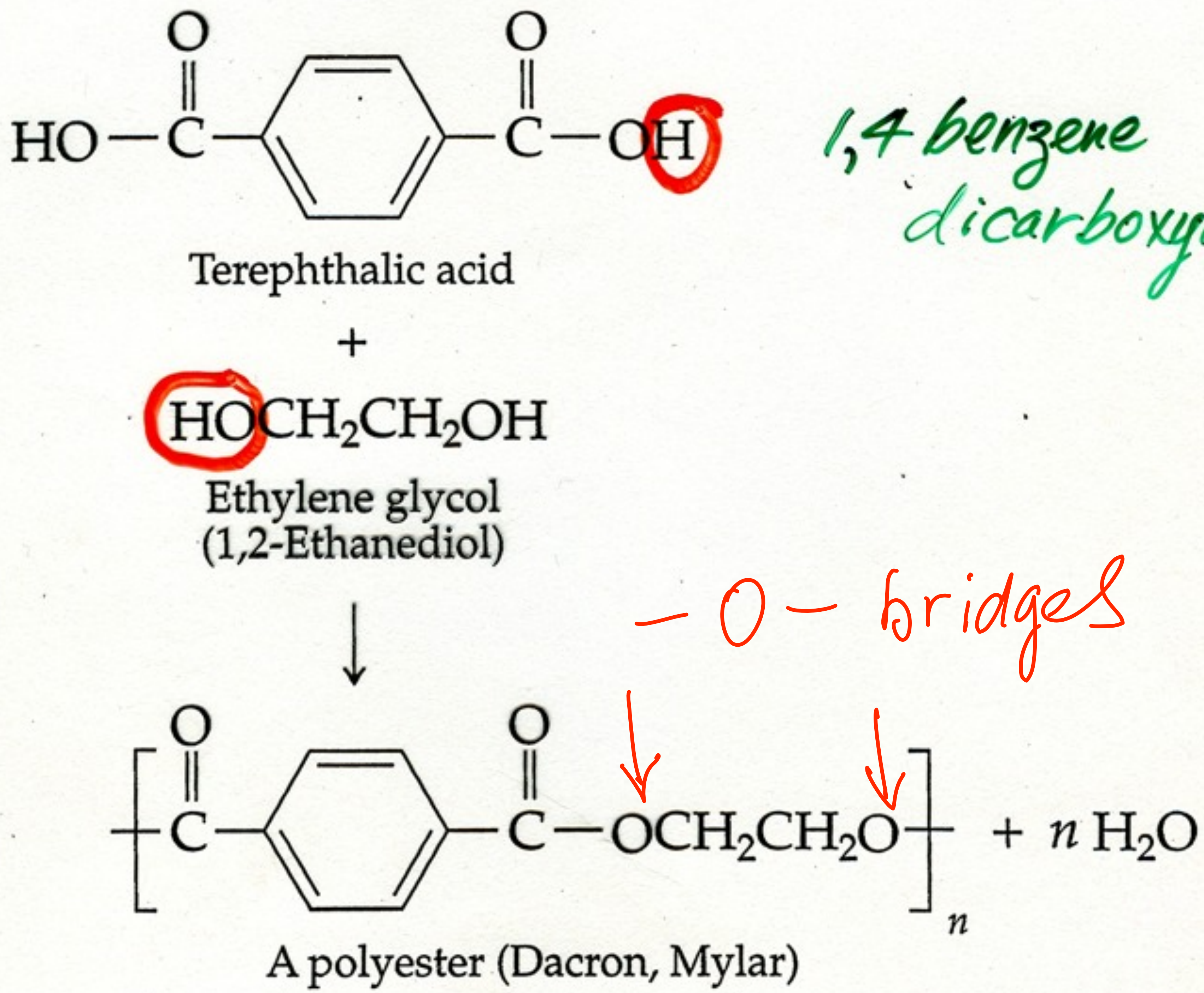


TABLE P.I Common Addition Polymers

Structure	*Chemical Name*	*Trade Name or Common Name*
$(-CH_2-CH_2-)_n$	polyethylene	
$(-CF_2-CF_2-)_n$	poly(tetrafluoroethylene)	Teflon
$(-CH_2-CH(CH_3)-)_n$	polypropylene	Herculon
$(-CH_2-C(CH_3)_2-)_n$	polyisobutylene	butyl rubber
	polystyrene	
$(-CH_2-CH(CN)-)_n$	polyacrylonitrile	Orlon
$(-CH_2-CH(Cl)-)_n$	poly(vinyl chloride)	PVC
$(-CH_2-CH(CO_2CH_3)-)_n$	poly(methyl acrylate)	
$(-CH_2-C(CH_3)(CO_2CH_3)-)_n$	poly(methyl methacrylate)	Plexiglas, Lucite
$(-CH_2-C(H){=}C(H)-CH_2-)_n$	polybutadiene	
$(-CH_2-C(Cl){=}CH-CH_2-)_n$	polychloroprene	neoprene
$(-CH_2-C(H){=}C(CH_3)-CH_2-)_n$ (H and CH_3 on the same side)	poly(*cis*-1,4-isoprene)	natural rubber
$(-CH_2-C(H){=}C(CH_3)-CH_2-)_n$ (H above, CH_3 below)	poly(*trans*-1,4-isoprene)	gutta percha

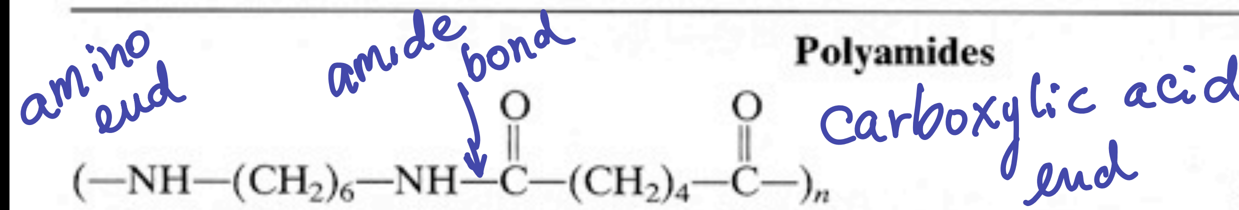
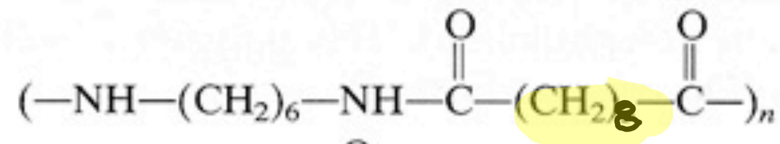
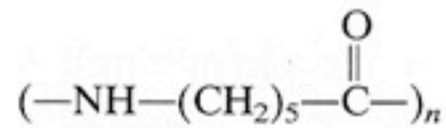
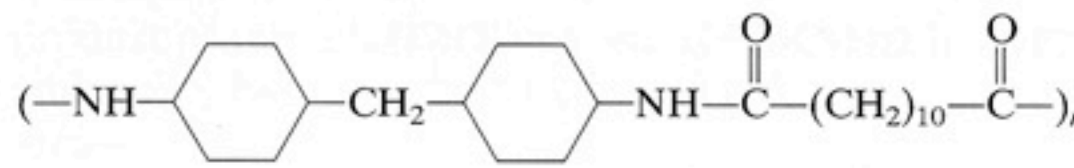
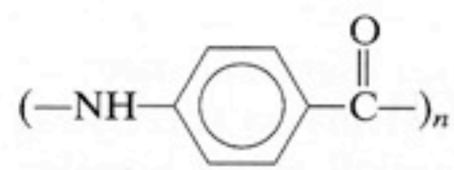
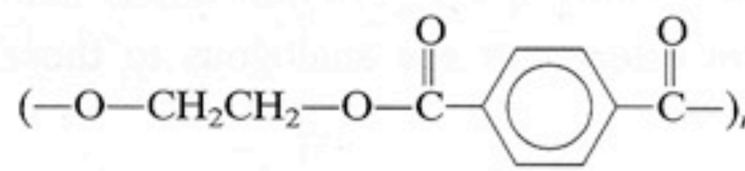
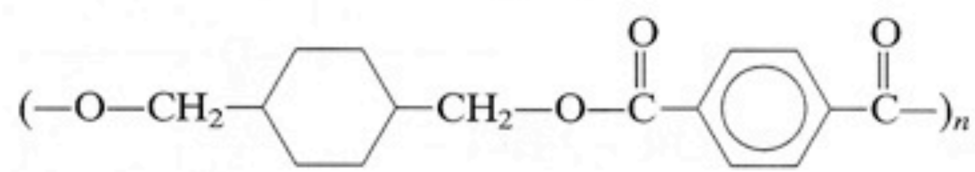
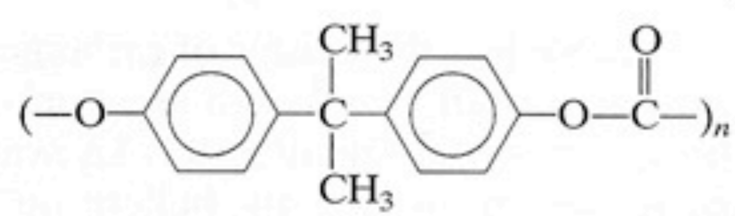
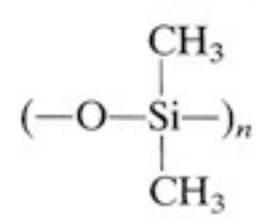
View as acid/base reaction



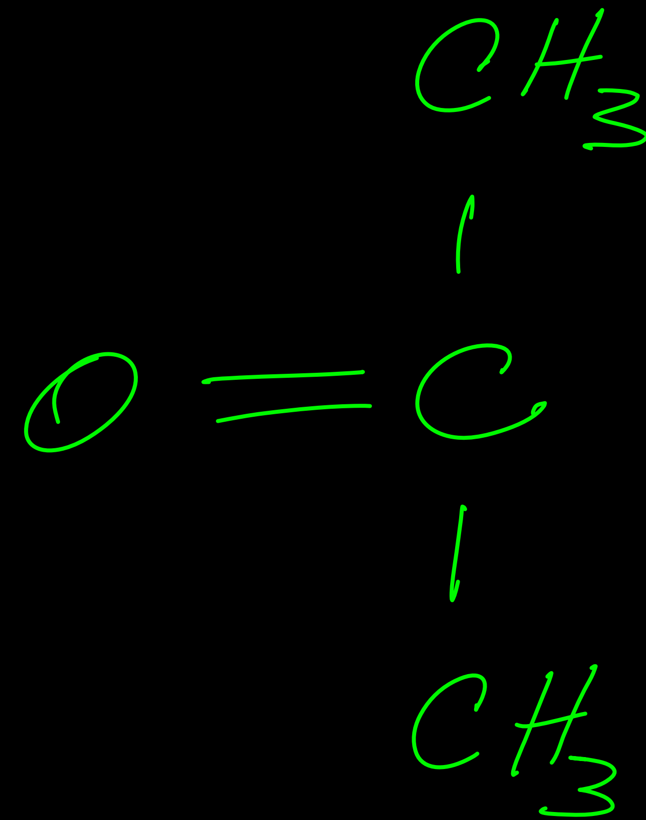
1,4 benzene dicarboxylic acid

poly(ethylene terephthalate) PET

TABLE P.2 Common Condensation Polymers

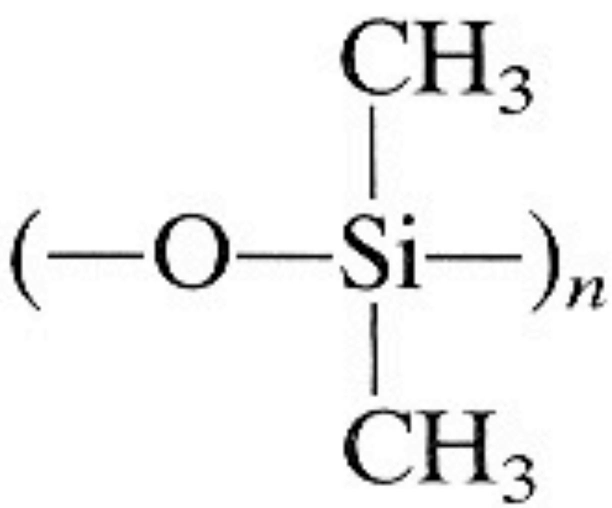
Structure	*Trade Name or Common Name*
Polyamides	
	Nylon 6, 6
	Nylon 6, 10
	Nylon 6
	Qiana
Polyaramides	
	Kevlar
Polyesters	
	Dacron, Mylar
	Kodel
Polycarbonates	
	Lexan
Silicones Siloxanes	
	silicone rubber

Ketone

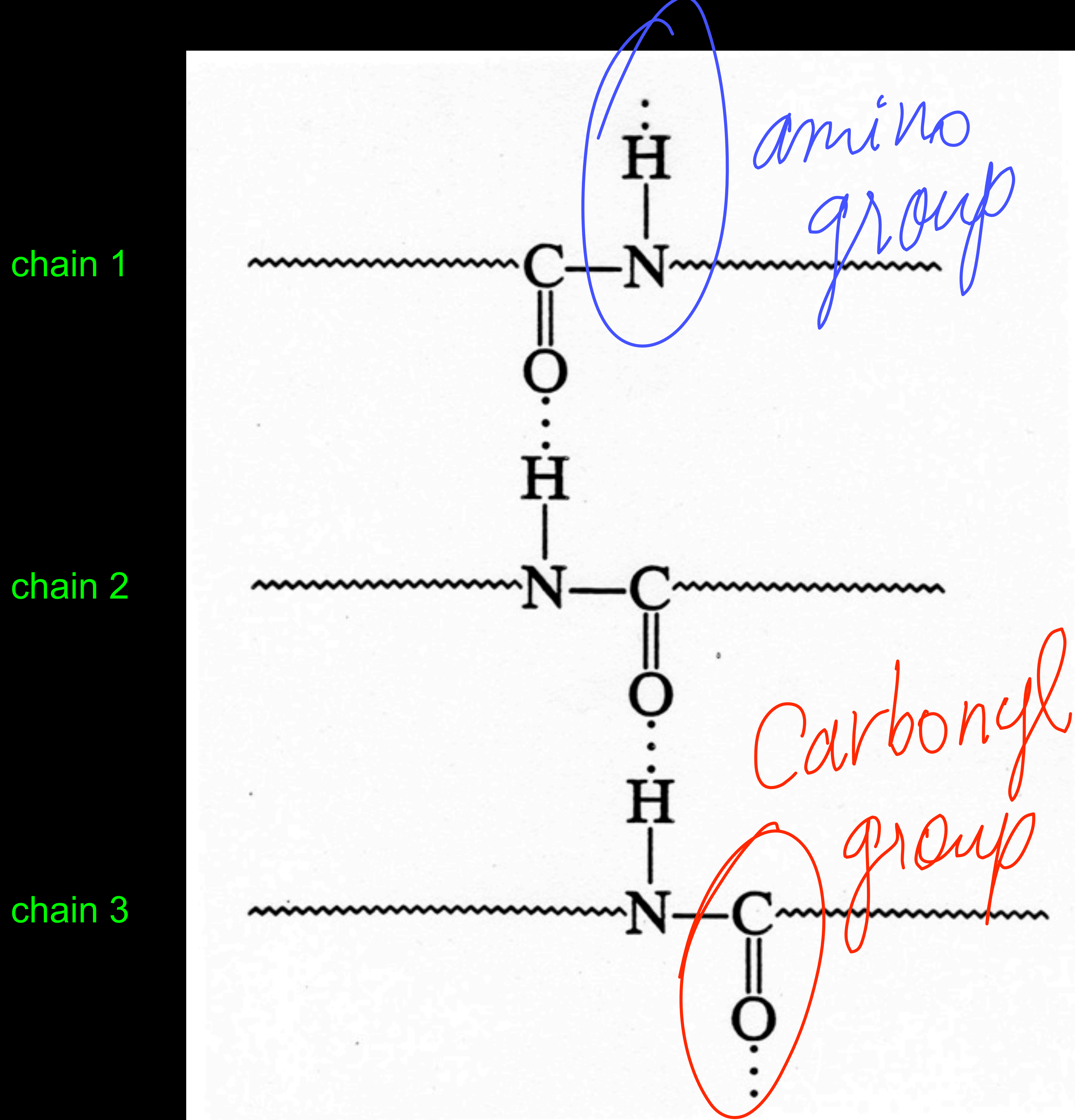


acetone

Siloxanes **Silicones**



poly(dimethylsiloxane) PDMS


chain 1
chain 2
chain 3
amino group
Carbonyl group

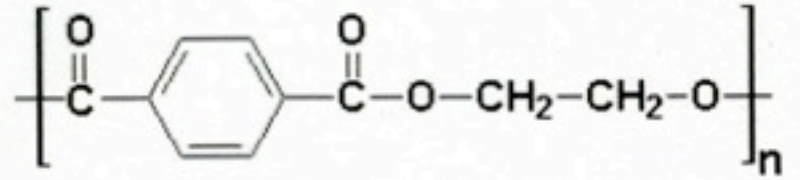
“Mister Cellophane” from the musical *Chicago*

Image from the film *Chicago* removed due to copyright restrictions.

Polythene Pam

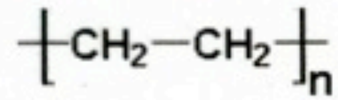
(Lennon/McCartney)

"Polythene Pam." The Beatles. *Abbey Road* (1969).



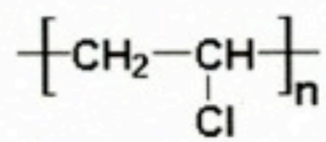
poly(ethylene terephthalate) (PET)

Invented by J.R. Whinfield and J.T. Dickson, 1940.
Uses: clothing, plastic films, plastic bottles



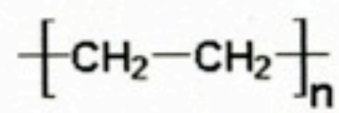
high-density polyethylene (HDPE)

Invented by Robert L. Banks and J. Paul Hogan, 1951.
Uses: plastics of all kinds, high-strength fibers



poly(vinyl chloride)

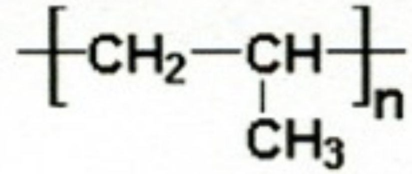
Invented by Waldo Semon, 1926.
Uses: water pipes, LP records, vinyl car tops



low-density polyethylene (LDPE)

Invented by Eric Fawcett and Reginald Gibson, 1935.
Uses: plastic films, bags

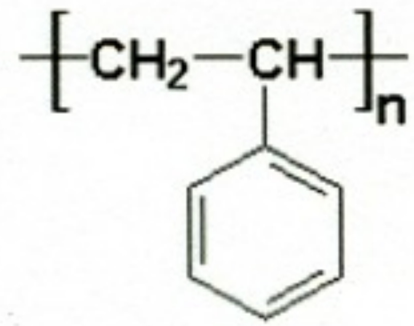
5
PP



polypropylene (PP)

Invented by Robert L. Banks and J. Paul Hogan, 1951.
Uses: fibers for rope, indoor-outdoor carpeting, plastics

6
PS



polystyrene (PS)

Invented by Eduard Simon, 1839.
Uses: rigid plastics of all kinds, polystyrene foams

Hermann Staudinger 1922 (Nobel 1953)

7
OTHER

anything else, including items made from more than one kind of polymer

Wallace Carothers

* b. April 27, 1896, Burlington, Iowa
* B.S., Tarkio College (gen. sci. & Eng.)
* Ph.D., U. of Illinois
* lecturer Harvard
* head of fundamental research in organic chemistry at DuPont; synthesis of long-chain molecules similar to cellulose and silk
* invented neoprene 1931: ☞synthetic rubber
* invented nylon 1937: ☞synthetic fiber
* m. February 1936
* d. April 29, 1937, Philadelphia

62 technical publications

69 patents

Wallace Carothers (1896 – 1937)

nylon rope pull:

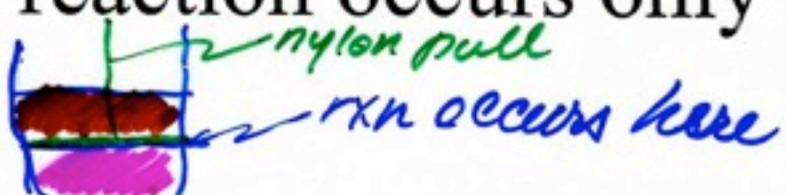
* beaker synthesis of nylon 6,6 by condensation polymerization:

hexamethylene diamine + adipic acid

⇨ nylon 6,6 + water

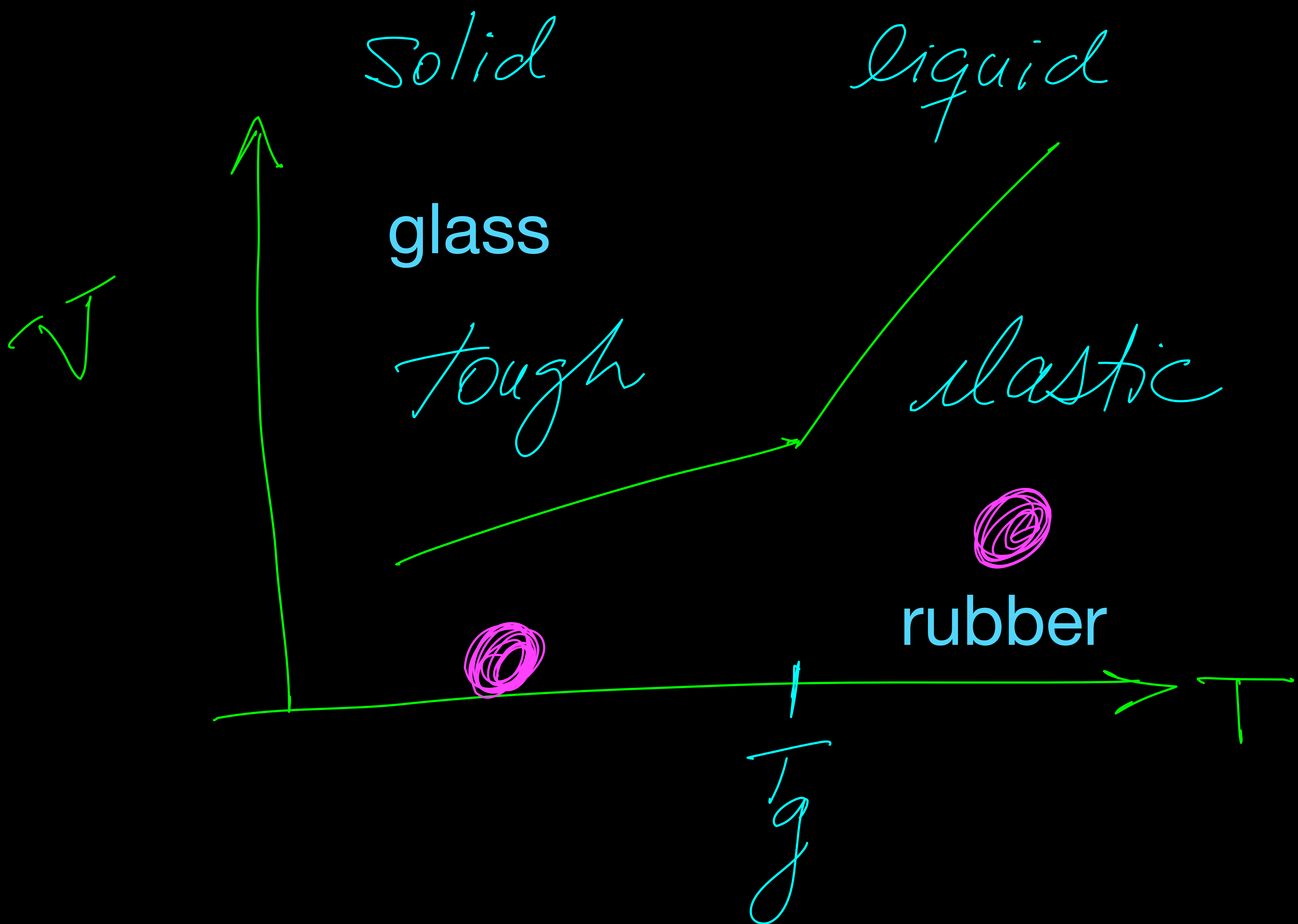
* industrially this reaction is conducted at 280ºC in the absence of solvents

* lab demo uses two immiscible solvents (water and hexane) and dissolves a reactant in each: reaction occurs only at the interface



$$H_2N\text{-}(CH_2)_6\text{-}NH_{2(aq)} + HO_2C\text{-}(CH_2)_4\text{-}CO_2H_{(\mathit{hexane})}$$

$$\Rightarrow \text{-}NH(CH_2)_6NH\text{-}\underset{\underset{O}{\|}}{C}(CH_2)_4\underset{\underset{O}{\|}}{C}\text{-} + H_2O$$



Solid
liquid
glass
V
tough
elastic
rubber
T
Tg

	(°C)	norbornene	isoprene
b.p. H_2O	100	elastic	elastic
T_g norbornene	40		
room temp	21	tough	elastic
T_g isoprene	-70		
b.p. N_2	-196	tough	tough

pattern of adoption

wonder
substitution
innovation
concern

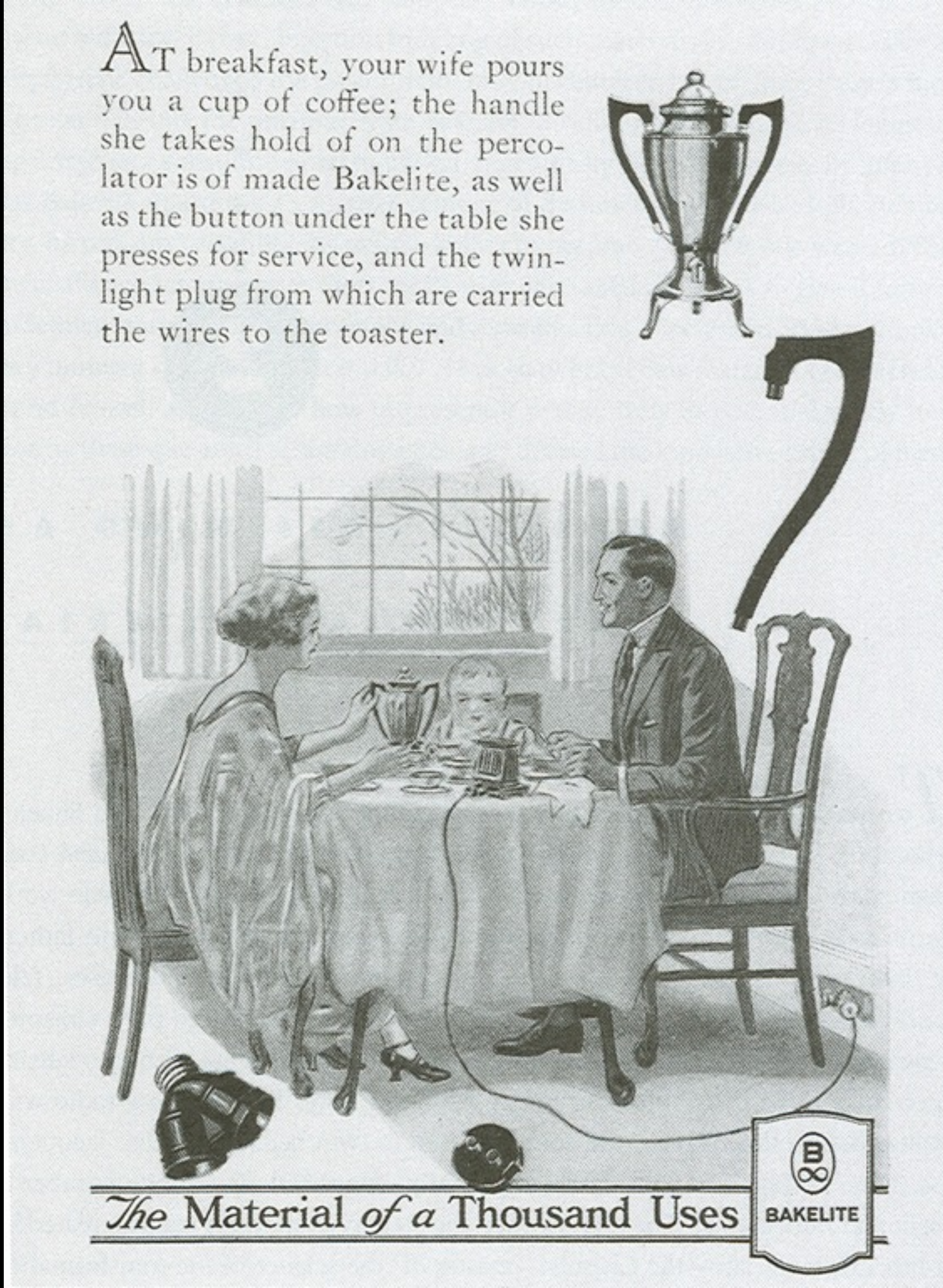
carbolic acid

+

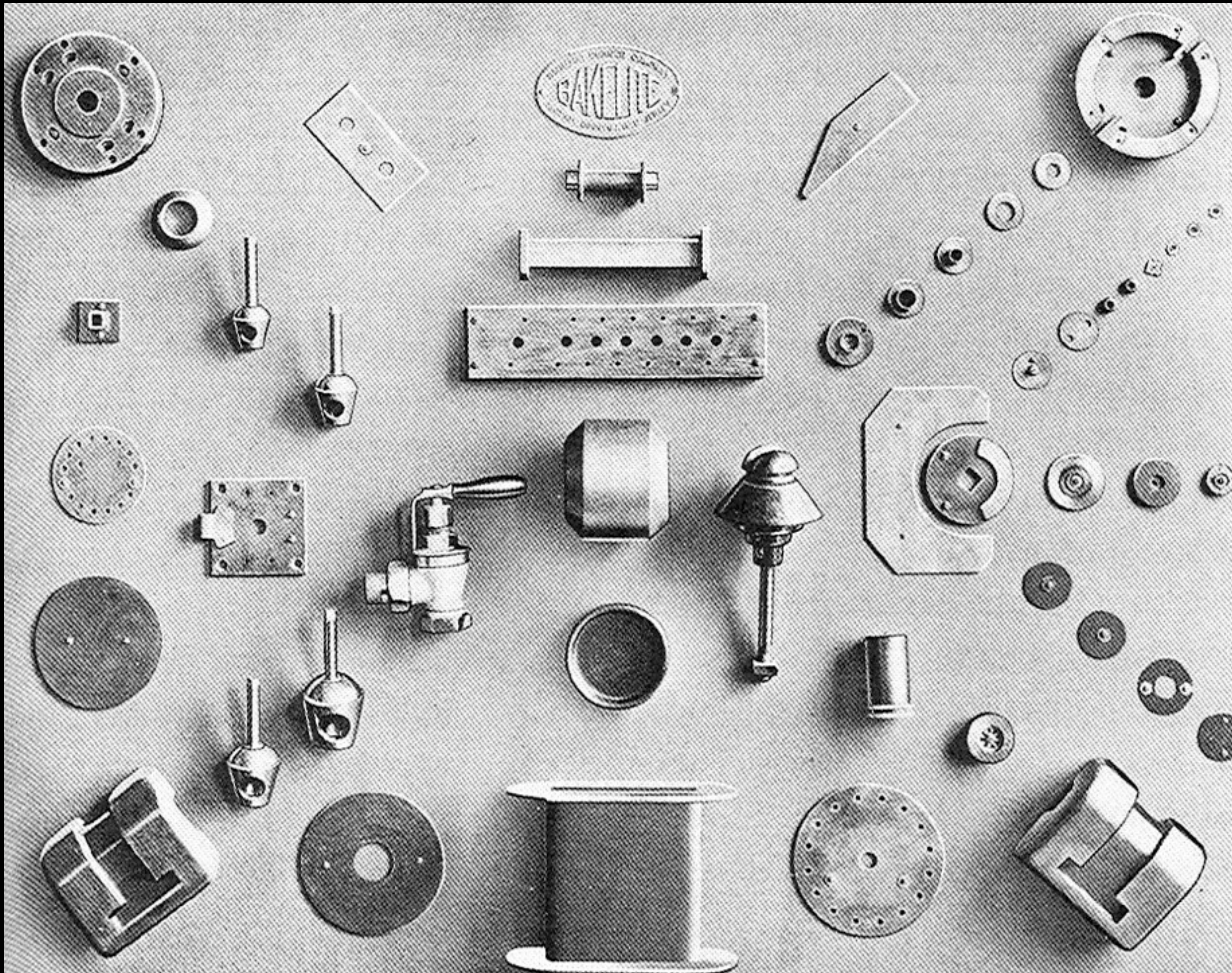
formaldehyde

☞

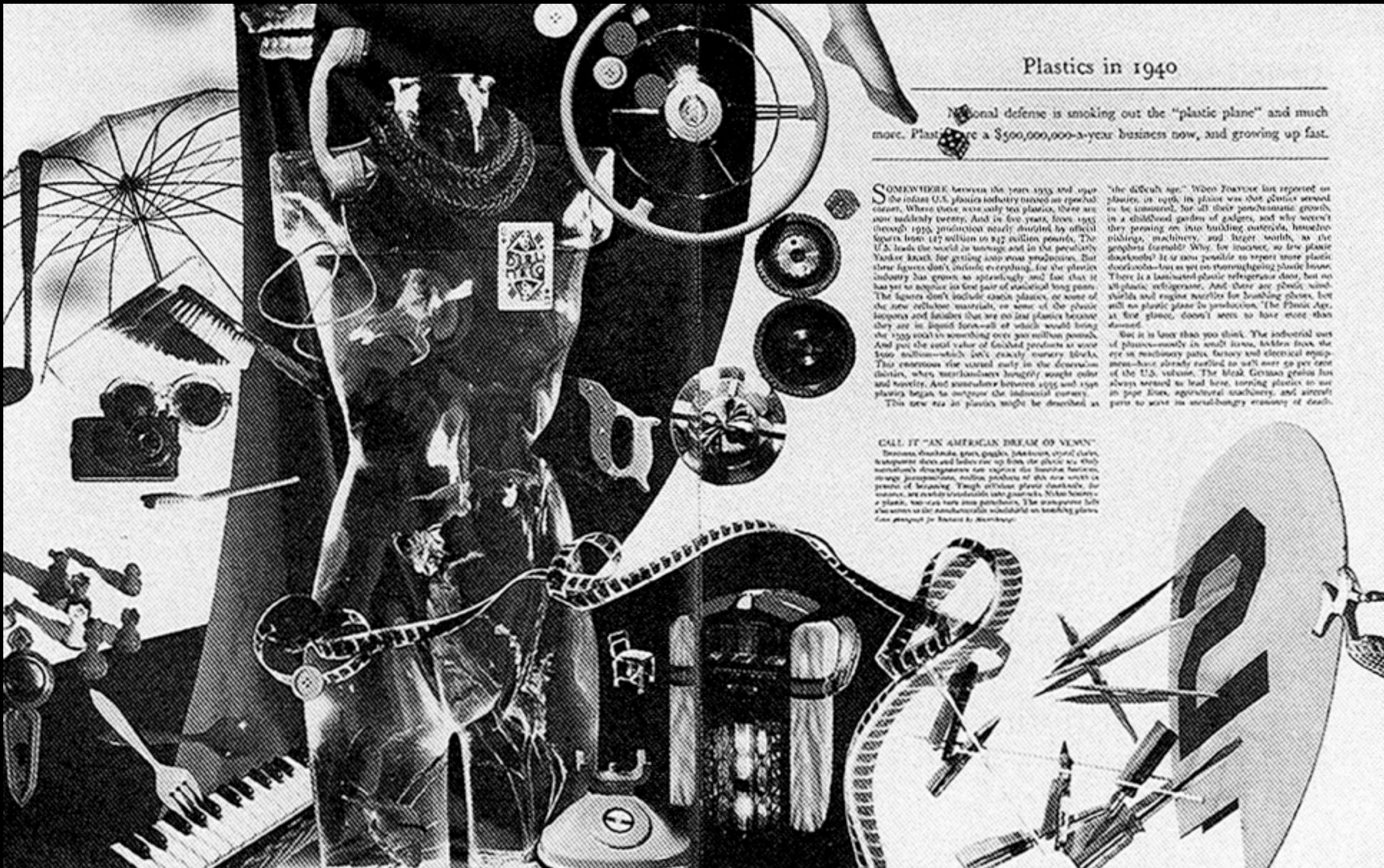
phenolic resin

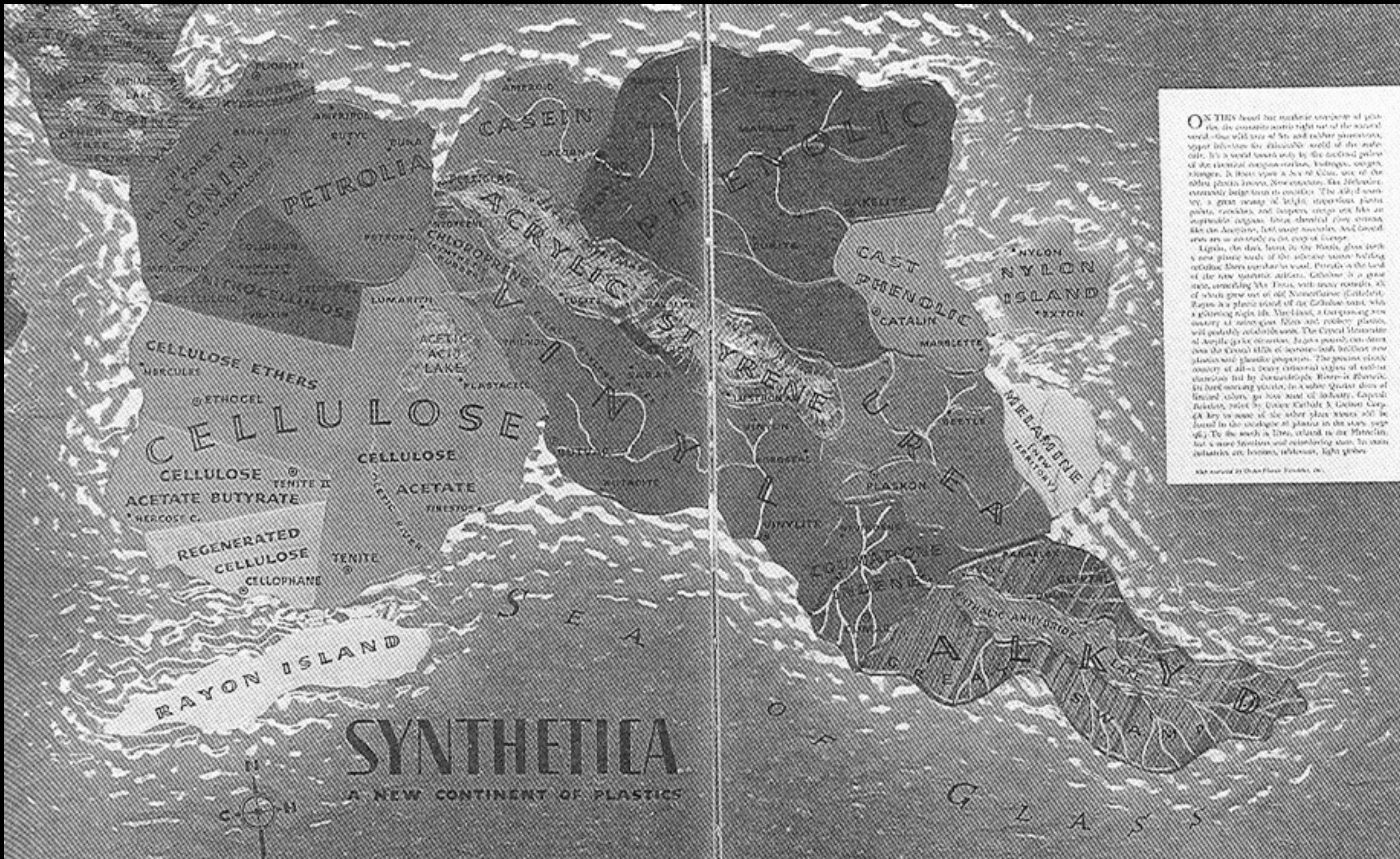


Advertisement, 1926.

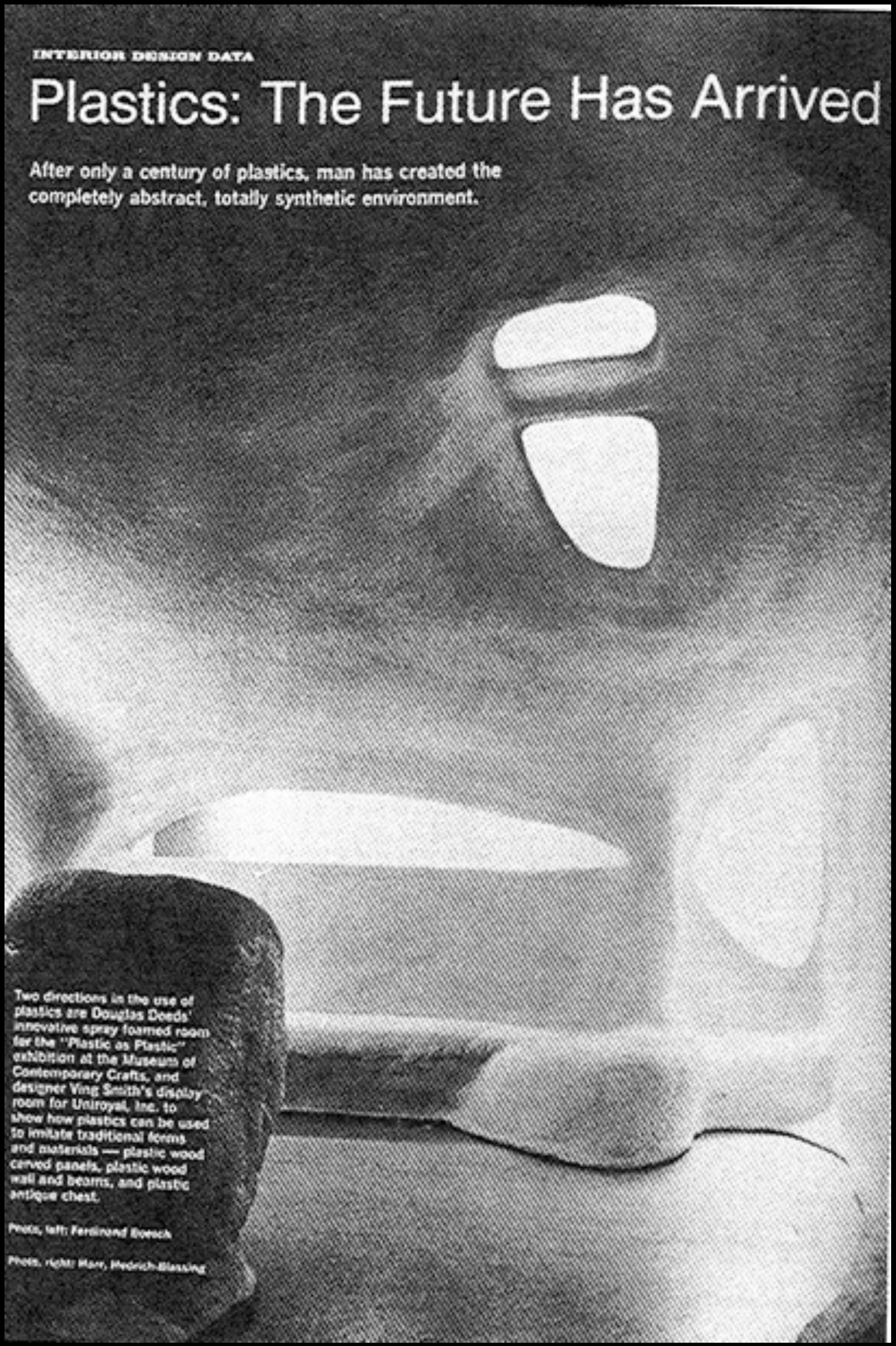


Promotional photo, 1909.


Plastics in 1940
N onal defense is smoking out the "plastic plane" and much more. Plasti re a $500,000,000-a-year business now, and growing up fast.


SYNTHETICA
A NEW CONTINENT OF PLASTICS
CASEIN
PETROLIA
LIGNIN
NITROCELLULOSE
CELLULOSE ETHERS
ETHOCEL
CELLULOSE
CELLULOSE ACETATE BUTYRATE
TENITE II
CELLULOSE ACETATE
REGENERATED CELLULOSE
CELLOPHANE
TENITE
RAYON ISLAND
ACETIC ACID LAKE
LUMARITH
CHLOROPRENE
ACRYLIC
VINYL
STYRENE
PHENOLIC
BAKELITE
CAST PHENOLIC
CATALIN
MARBLETTE
NYLON
NYLON ISLAND
EXTON
MELAMINE (NEW TERRITORY)
UREA
BEETLE
PLASKON
VINYLITE
PHTHALIC ANHYDRIDE
ALKYD
SEA
SEA OF GLASS

room of sprayed polyurethane foam by Douglas Deeds for “Plastic as Plastic” exhibition at Museum of Contemporary Crafts, New York, 1968


INTERIOR DESIGN DATA

Plastics: The Future Has Arrived

After only a century of plastics, man has created the completely abstract, totally synthetic environment.

Two directions in the use of plastics are Douglas Deeds' innovative spray foamed room for the "Plastic as Plastic" exhibition at the Museum of Contemporary Crafts, and designer Ving Smith's display room for Uniroyal, Inc. to show how plastics can be used to imitate traditional forms and materials — plastic wood carved panels, plastic wood wall and beams, and plastic antique chest.

Photo, left: Ferdinand Boesch

plastic

- the Greek πλασσειν = to shape
  - ☞ cognates include "potter"
  - ☞ πλαστικος = can be shaped (malleable?)
- Samuel Johnson wrote:

  "Benign Creator, let Thy plastick hand
  Dispose its own effect."

US annual prod^{n} of polymers:

100 billion lb = 50 million tons

3 - 4 million tons recycled

cf. steel - US annual prod^{n}:

140 million tons

- 80 million tons virgin metal
- 60 million tons recycled scrap

US annual prod^{n} of polymers:

100 billion lb = 50 million tons

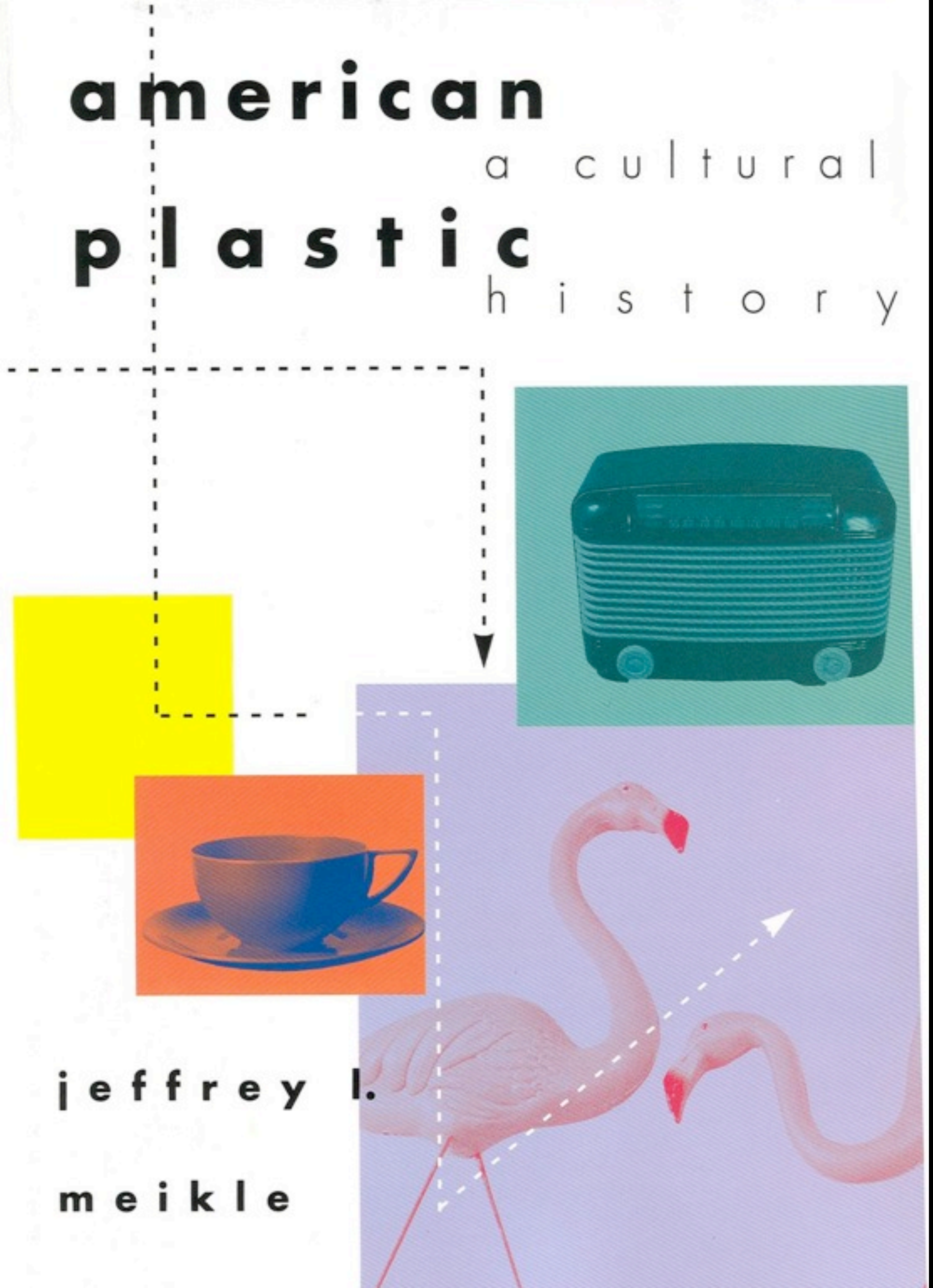
3 - 4 million tons recycled

cf. aluminum - US annual prod^{n}:

4 million tons

1 million tons recycled

62% return rate on UBCs (DFE)


american
a cultural
plastic
history
jeffrey l.
meikle