2005 PLACE Conference September 27-29 Las Vegas, Nevada

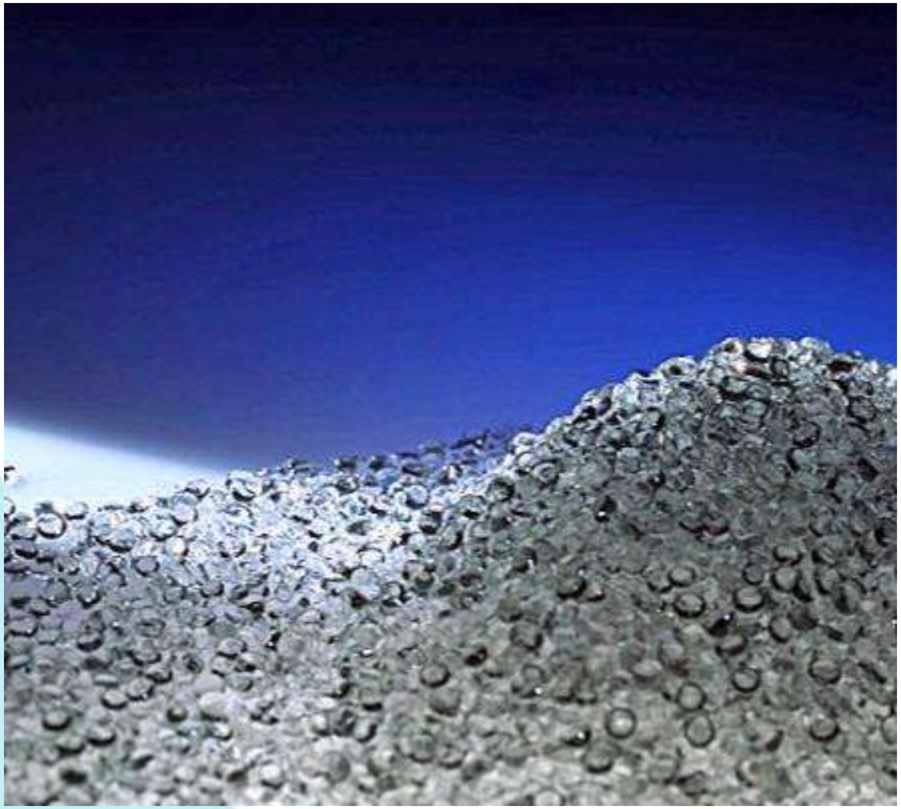
TOPAS® Cyclic Olefin Copolymers in Food Packaging – High Aroma Barrier Combined with Low Extractables

Presented by:

Randy Jester

Associate Engineer

TOPAS® COC
A New Addition to the Ethylene Copolymer Family



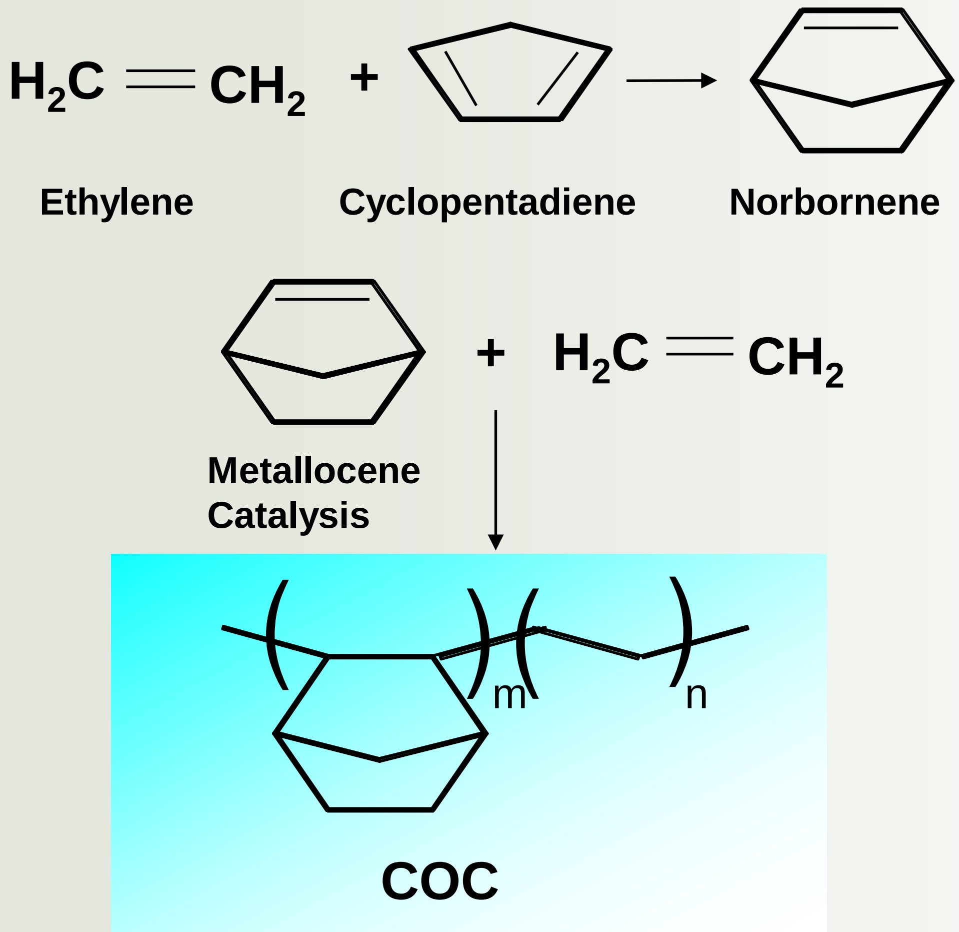
- Polyolefin Resin
- Amorphous
- Clear and Colorless
- High Purity
- High Moisture Barrier
- Good Chemical Resistance
- Easy to Process

Production Plant in Oberhausen, Germany

- Production plant on stream since Oct 2000
- 30 000 tons / year production capacity
- Backward integrated in Norbornene
- Largest Cyclic Olefin Copolymer (COC) plant in the world

Large scale production of COC enables the production of a cost competitive product for use in packaging applications

COC - Synthesis and Structure

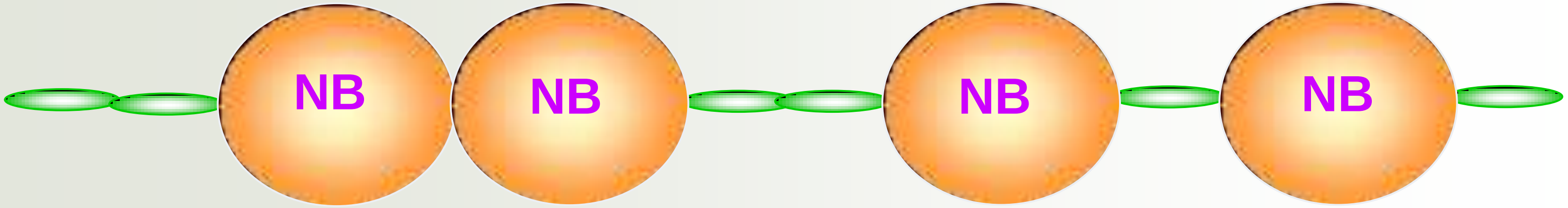


- **Readily available raw materials**
- **Highly efficient catalyst**
  - Low usage
  - Catalyst removed as part of process
  - High purity product
- **Amorphous**
- **Crystal clear**

COC is Amorphous

The COC molecule is a chain of small CH_2-CH_2 links randomly interspersed with large bridged ring elements

It cannot fold up to make a regular structure, i.e., a crystallite



COC has no crystalline melting point, but only a glass transition temperature, T_g , at which the polymer goes from “glassy” to “rubbery” behavior

COC - Basic Properties

Glass transition temperatures, °C(°F)	33 - 180 (91 – 356)
Modulus of elasticity, N/mm^2 (kpsi)	1260 – 3200 (180 – 460)
Tensile strength, N/mm^2 (kpsi)	25 - 63 (3.6 - 9.1)
Density, g/cm^3	1.02
Water uptake, %	< 0.01
WVTR, g-mil/100 in^2 × day (38°C/90%RH)	0.24 – 0.49

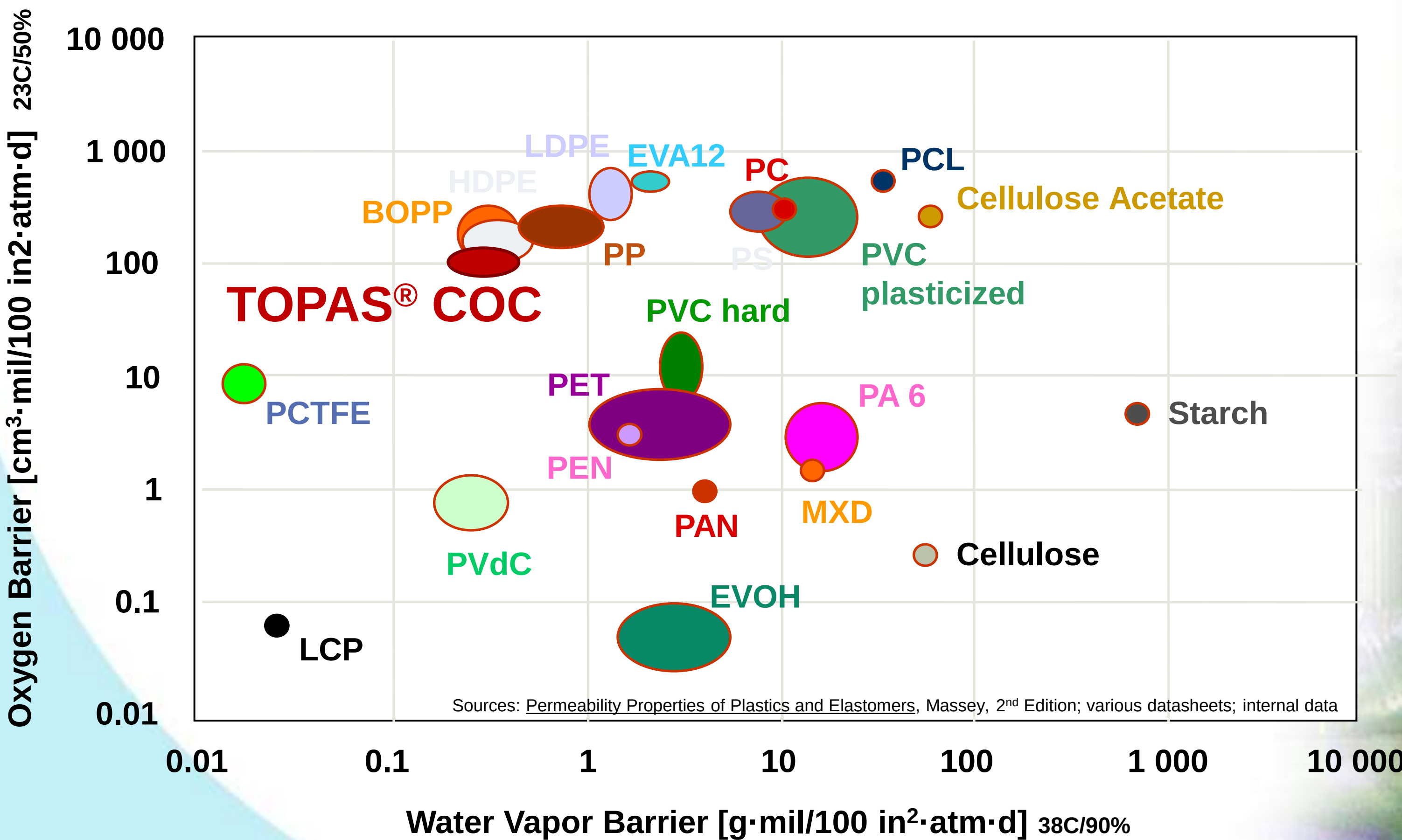
- Glass Clear, Transparent
- Sterilizable via Steam, EtO, gamma, beta (E-beam)
- Resistant to Alcohols, Acids, Bases, Polar Solvents
- High Purity, Low Extractables
- Low Water Transmission Rate (WVTR)
- Biocompatible
- Halogen-free

COC – Regulatory Status

- FDA Regulation 21 CFR 177.1520 (3.9)
- COC FDA Food Contact Notification (FCN #75) became effective August 22, 2000, covers films, sheets, and articles made therein from and molded articles for repeated use.
- COC FDA Food Contact Notification (FCN #405) became effective May 20, 2004, expands #75 to cover all applications, including bottles.
- FDA Drug Master File, DMF# 12132, established.
- FDA Device Master File, MAF# 1043, established.
- The monomers are listed in the EU Directive 2002/72/EG
  - Norbornene has a SML = 0.05 mg/kg.

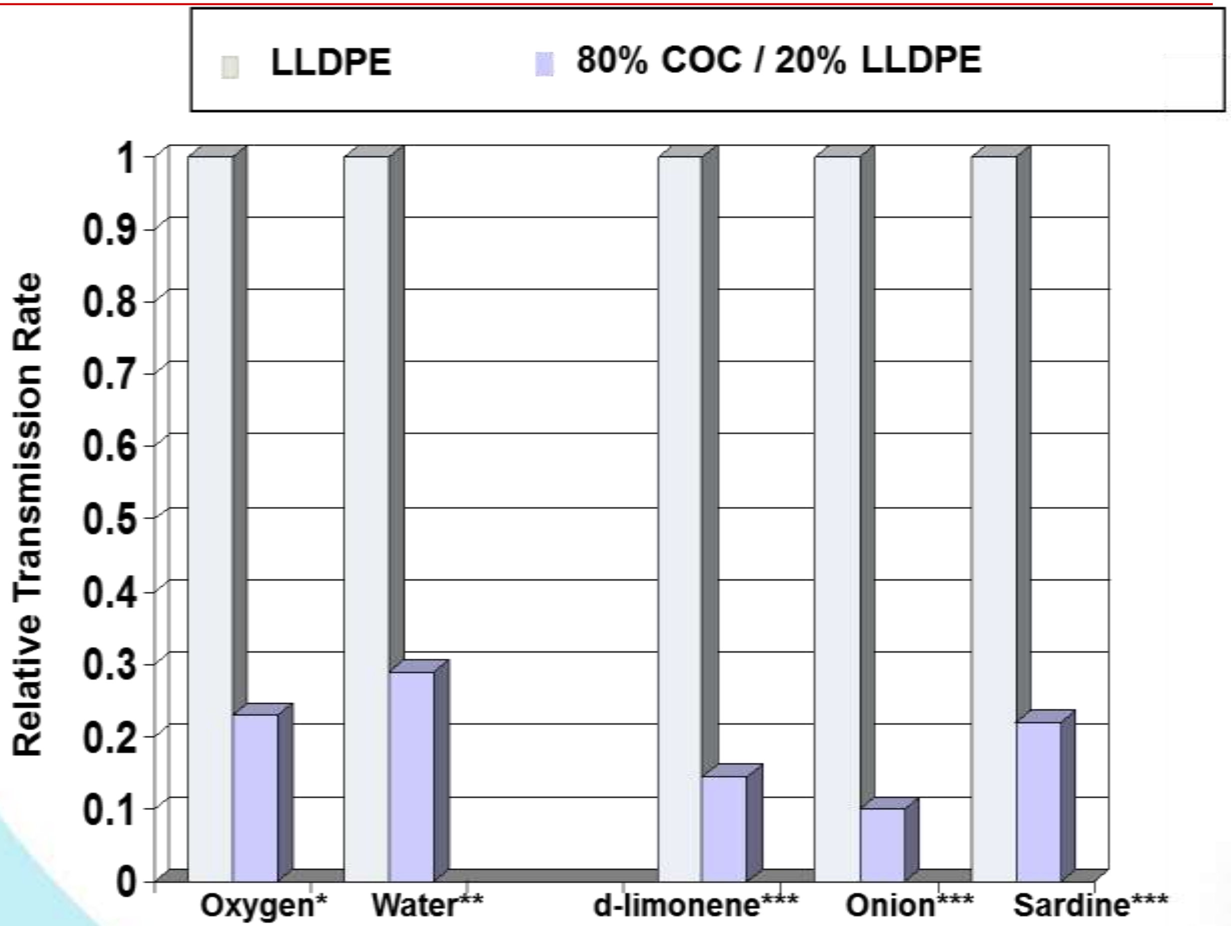
COC can meet all major regulatory requirements for food contact and medical use

TOPAS® COC - Barrier Properties



COC can extend the shelf life of products due to its very high moisture barrier

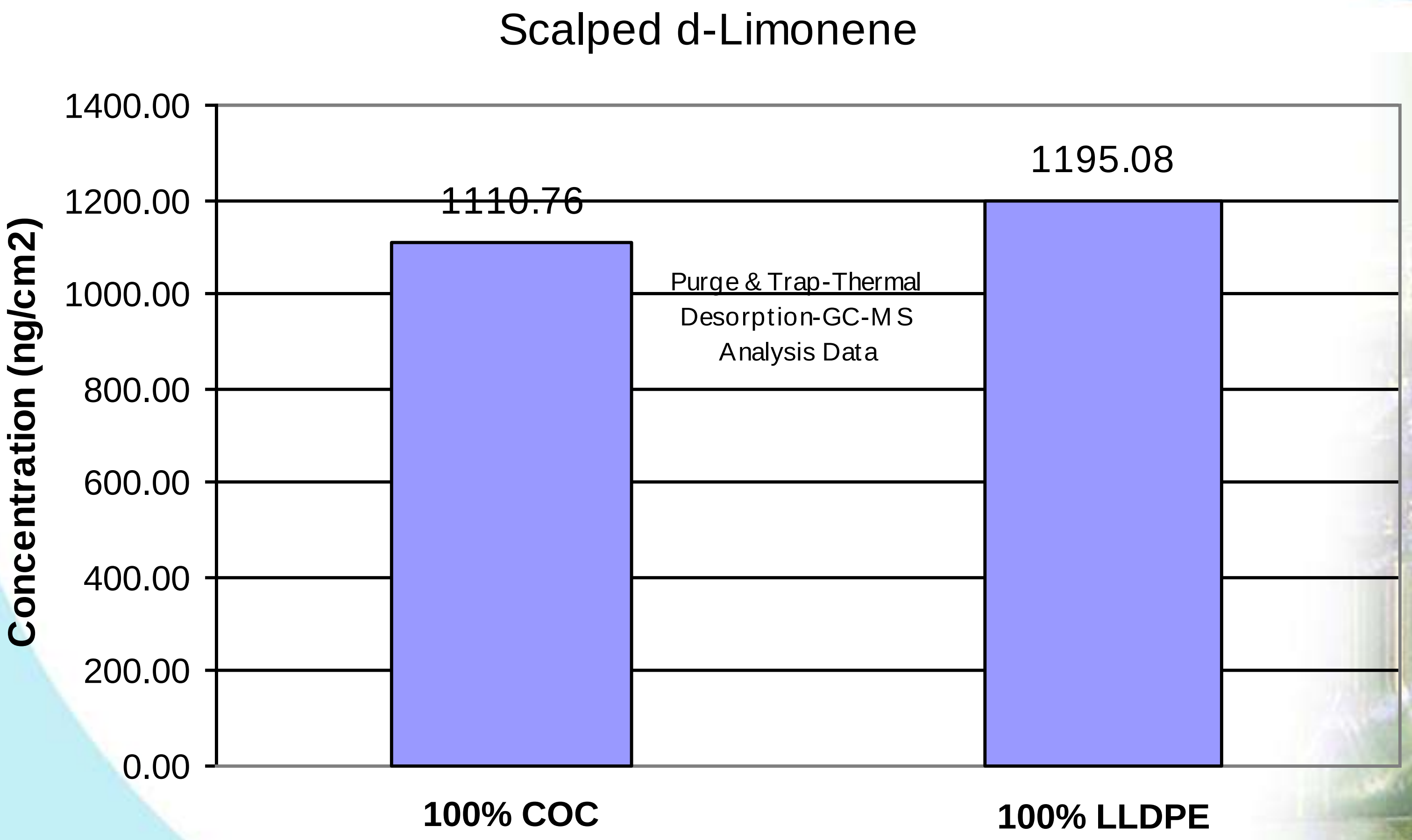
COC – A Barrier Polyolefin



* 23C & 50% RH
** 38C & 90% RH
*** 23C, MOCON technique, saturated vapor of "paste"

COC in LLDPE blends can reduce gas/vapor transmission rates by 70 – 90% at blend levels as low as 80%. This blend level typically achieves >90% of the barrier of 100% COC.

Reduced Flavor Scalping



Scalping of d-Limonene by COC is similar to that of LLDPE, indicating that the solubility of d-Limonene in COC is similar to that of LLDPE

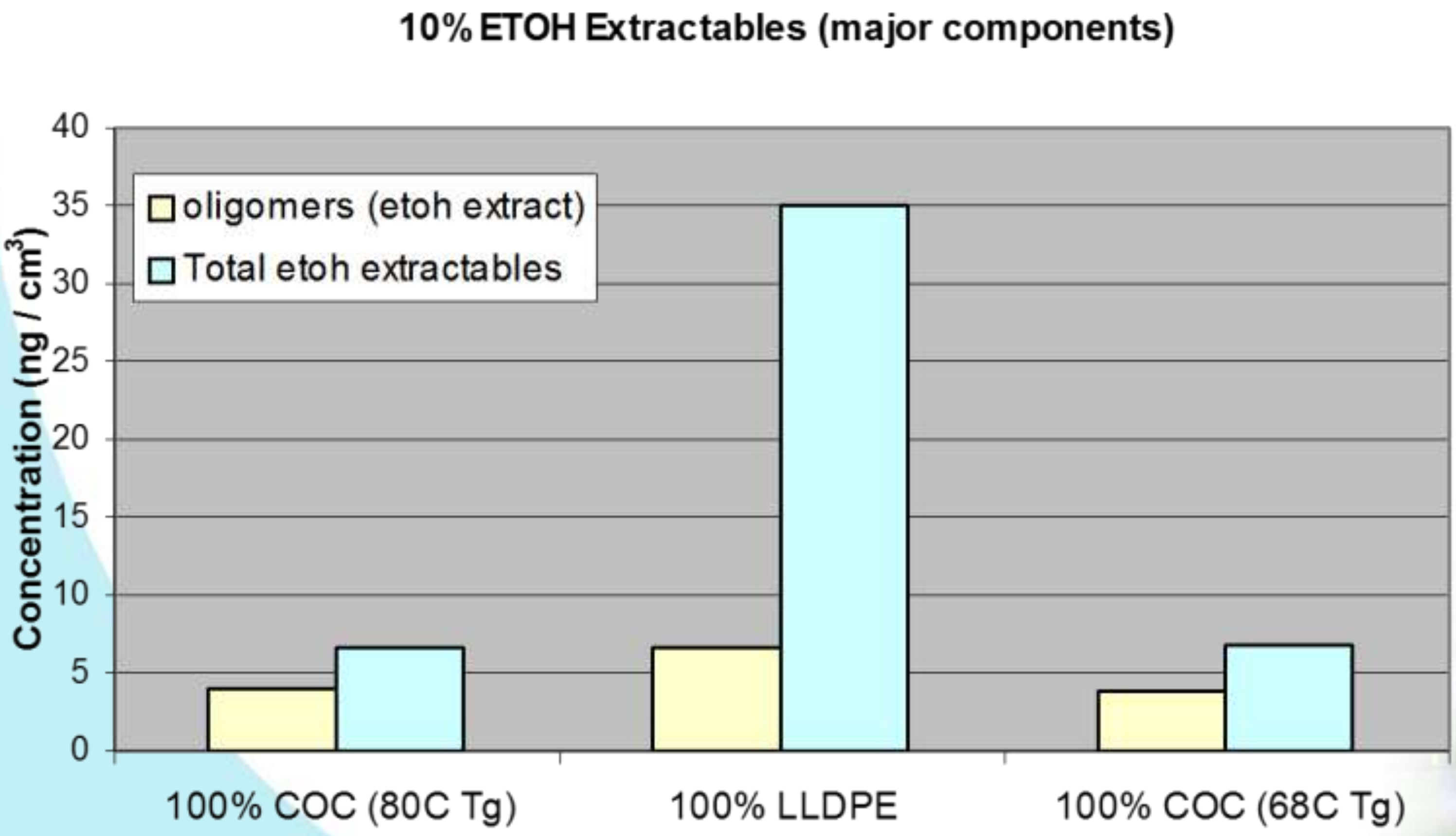
Factors Affecting Permeability

- Permeability (normalized transmission) is the product of diffusivity (kinetic factor) and solubility (thermodynamic factor).
- The similar levels of equilibrium scalping indicate that solubility of d-limonene is similar in LLDPE and COC.
- This information indicates that the primary factor affecting the reduced permeability of COC is diffusivity.

Glassy vs. Rubbery State

- The COC grades in this study have T_g's in the 68-80^oC range, well above the measurement conditions. LLDPE on the other hand has a T_g of –128^oC and is in a rubbery state.
- Polymers in the rubbery state typically have a higher free volume due to a high level of molecular mobility, which increases diffusion rates of permeants.
- Polyethylene and COC are both non-polar materials and would in general have similar solubility parameters for most permeants.
- It can be generalized that for many permeants, COC will produce an improved barrier as compared to polyethylene since it will typically be in the glassy state under use conditions.

Reduced Extractables



Elevated temperature (60ºC for 24 hours) extraction shows that COC has significantly lower extractables than LLDPE including about 50% lower oligomer levels which can produce off tastes in food

Conclusions

- COC has better aroma barrier than polyethylene and can reduce aroma/flavor loss from food when it is utilized as a barrier layer in food packaging.

- COC can also reduce the transmission of objectionable odors to surrounding areas and should have utility in disposable food storage bags.

- Low extractables in COC reduces the possibility of generating an “off-taste” in water or susceptible foods when used as a contact layer or just under a seal layer in packaging.