Asphaltene: A General Introduction

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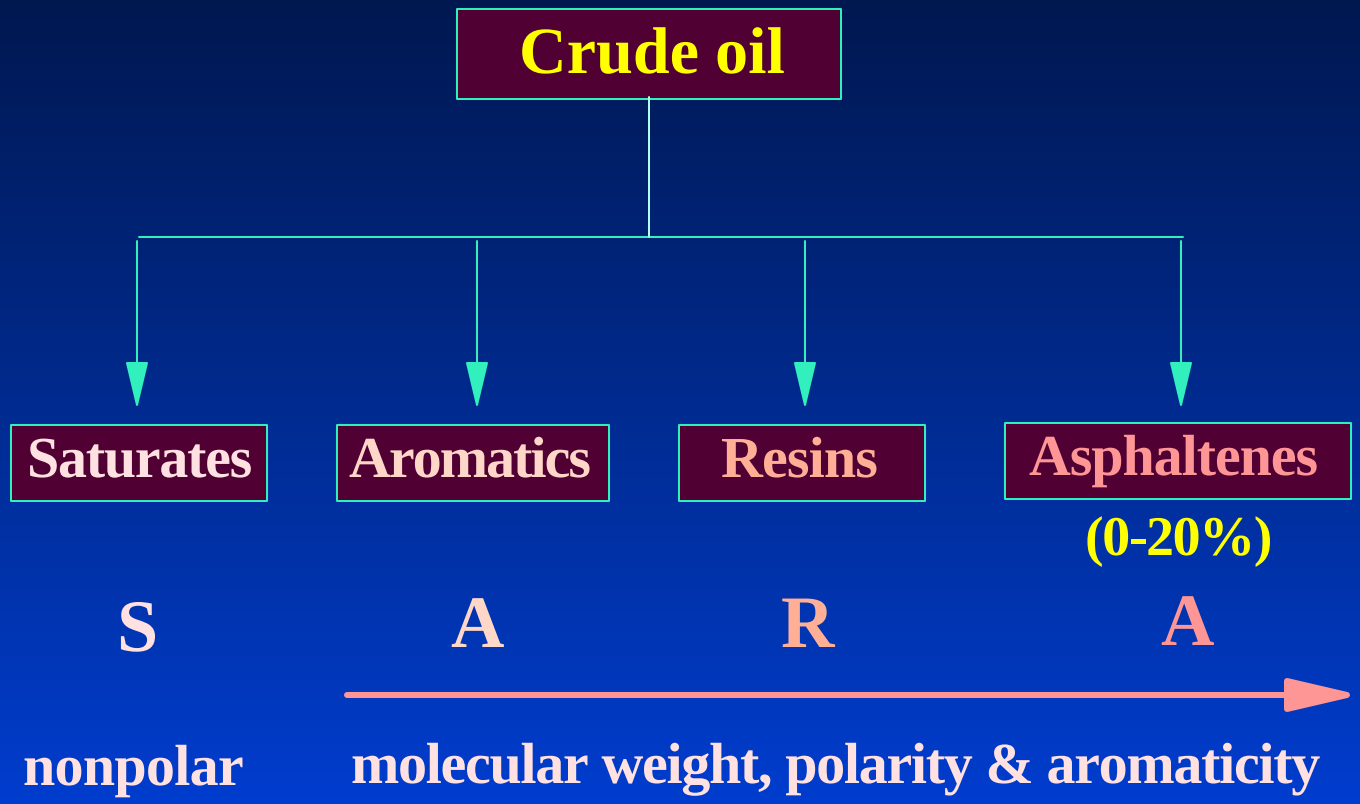
Outline

- **What is asphaltene?**
- **Why to study asphaltene?**
- **How to characterize asphaltene stability in crude oil?**

Asphaltenes are the most heavy and polar components in crude oil

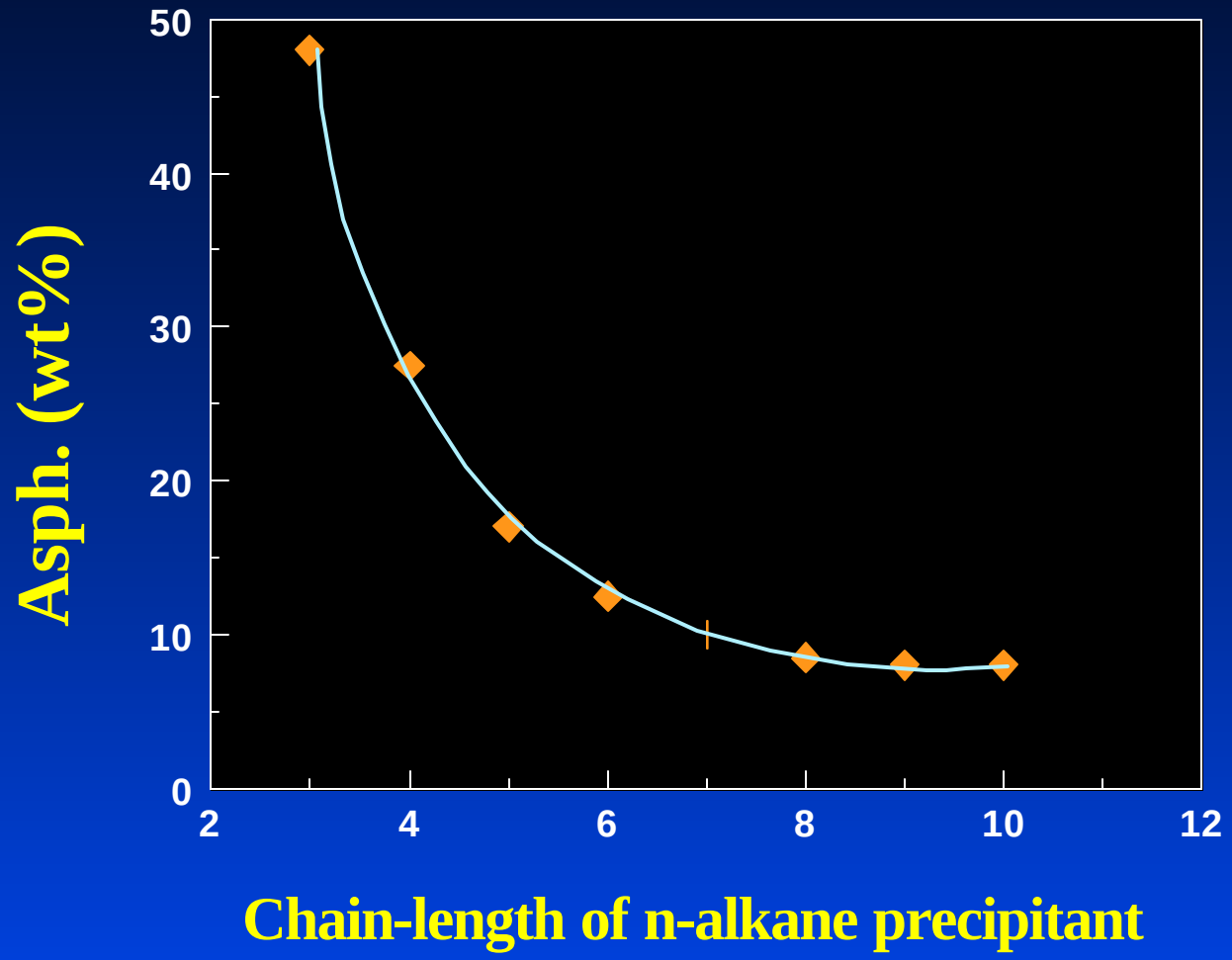


Separating asphaltene from crude oil

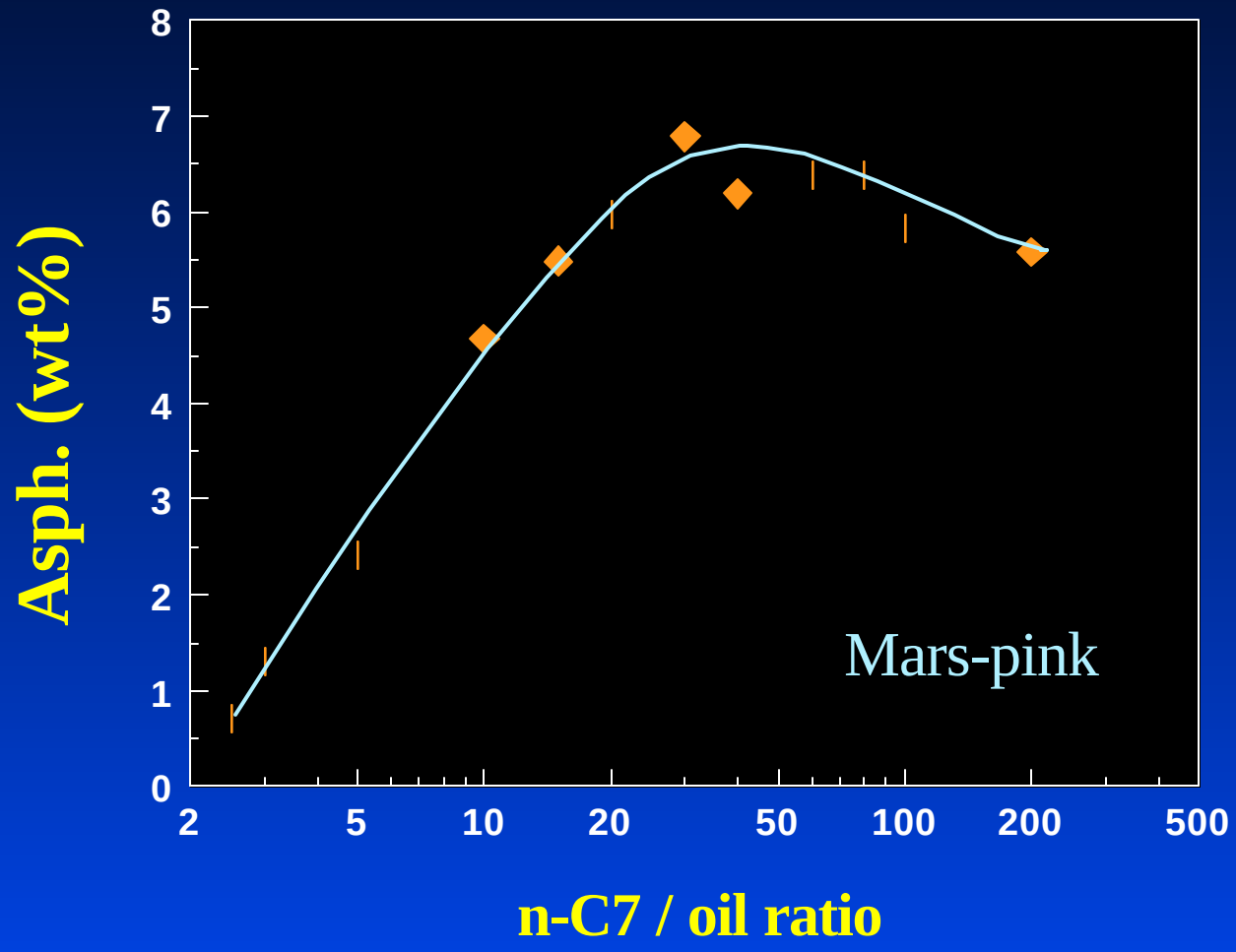
ASTM D2007-80:

- **Mixing crude oil / n-C7 (or n-C5) = 1 / 40**
- **Aging for two days**
- **Filtering through 0.22 ㎜ filter paper**

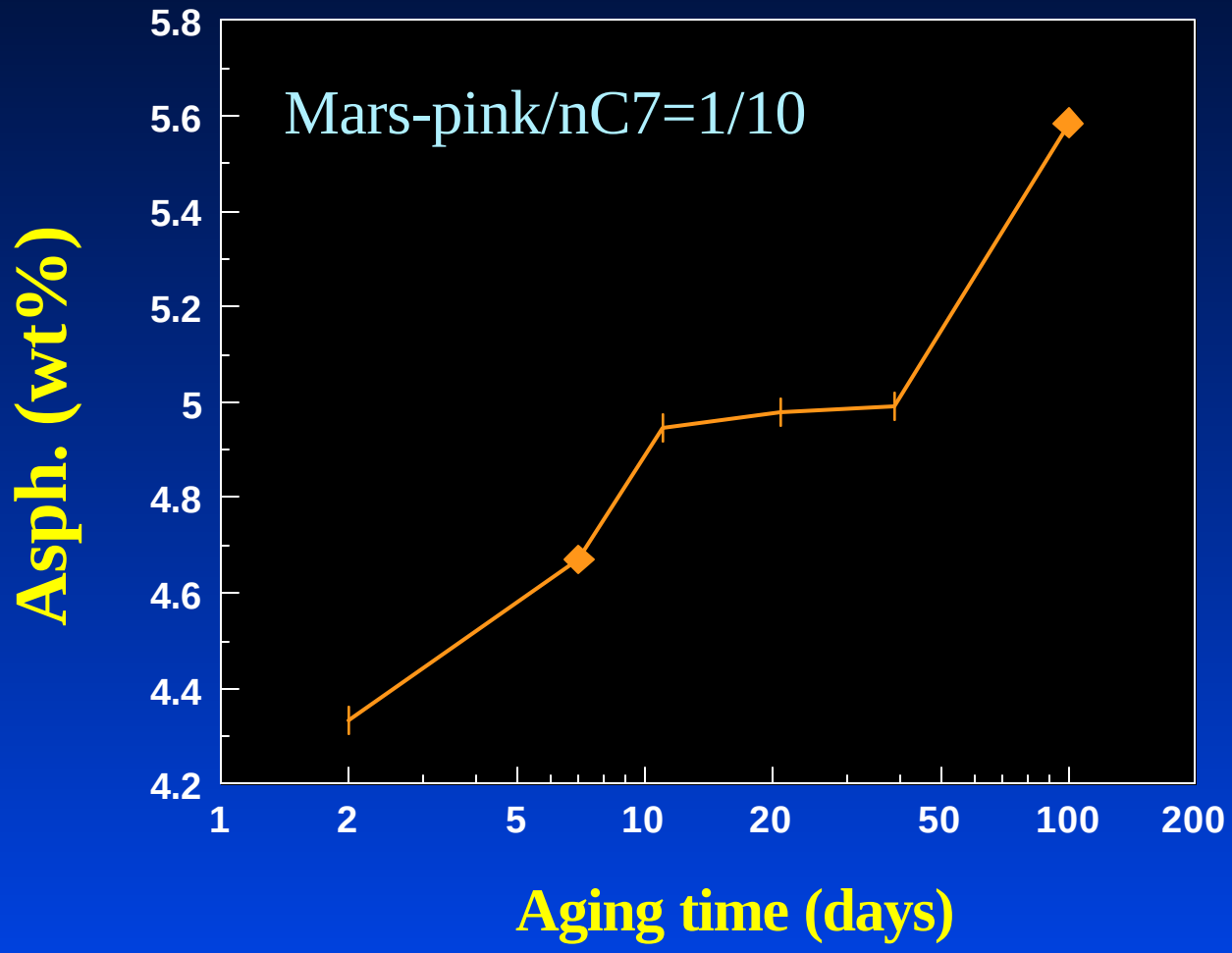
Separated asphaltene amount is determined by precipitant molecule size



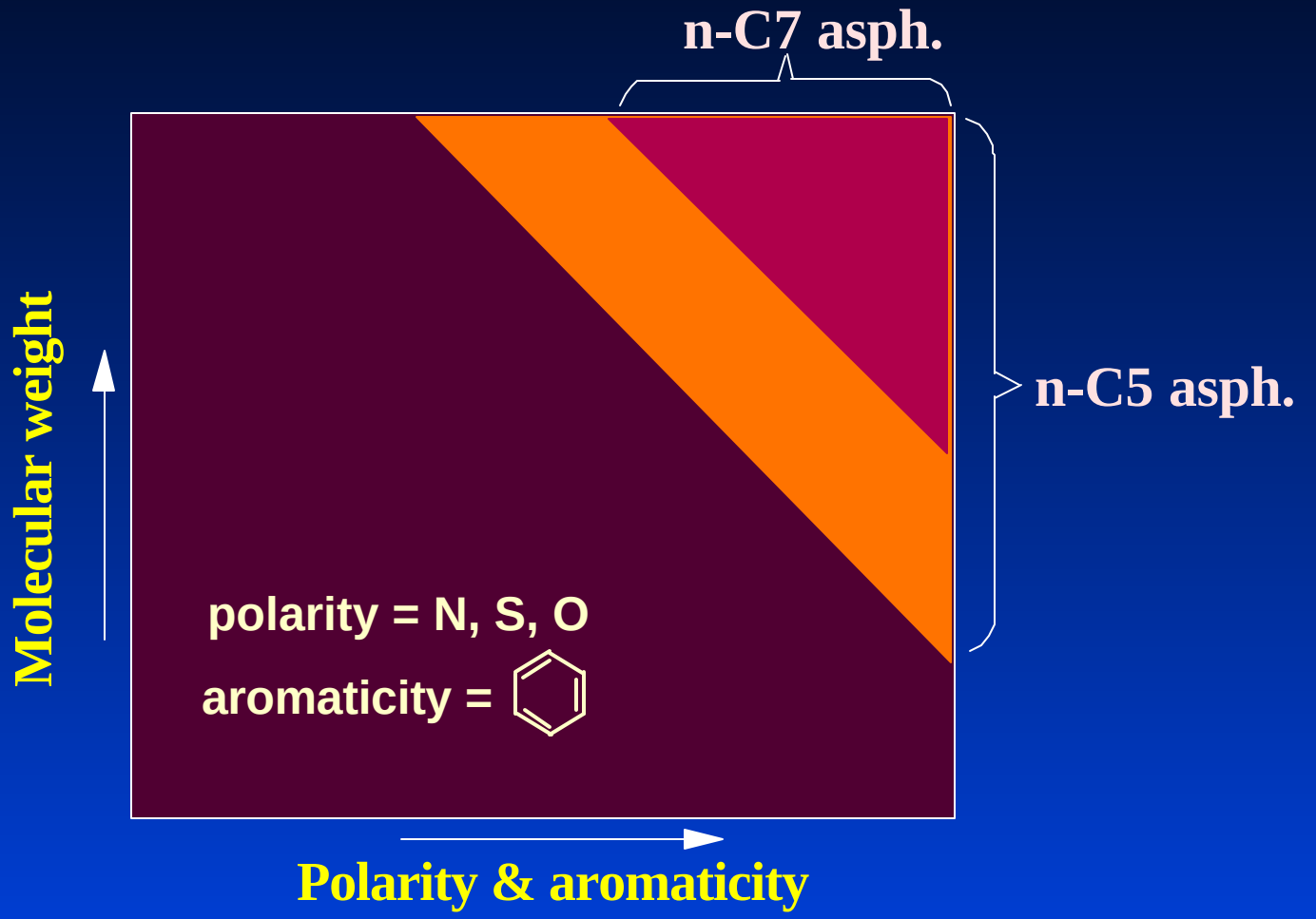
Separated asphaltene amount is also determined by precipitant/oil ratio



Furthermore, separated asphaltene amount is also time-dependent



Asphaltene is a compositional continuum



Long, R.B.: "The Concept of Asphaltenes," Chemistry of Asphaltenes, J.W. Bunger and N.C. Li (eds.), ACS, Washington, DC (1981) 17-27.

Typical asphaltene molecular properties

H/C = 0.8 - 1.4

Molecular weight:

depends on solvent and concentration

monomer = 500 - 1000

micelles = 1000 - 5000

Heteroatoms: acting as polar functional group

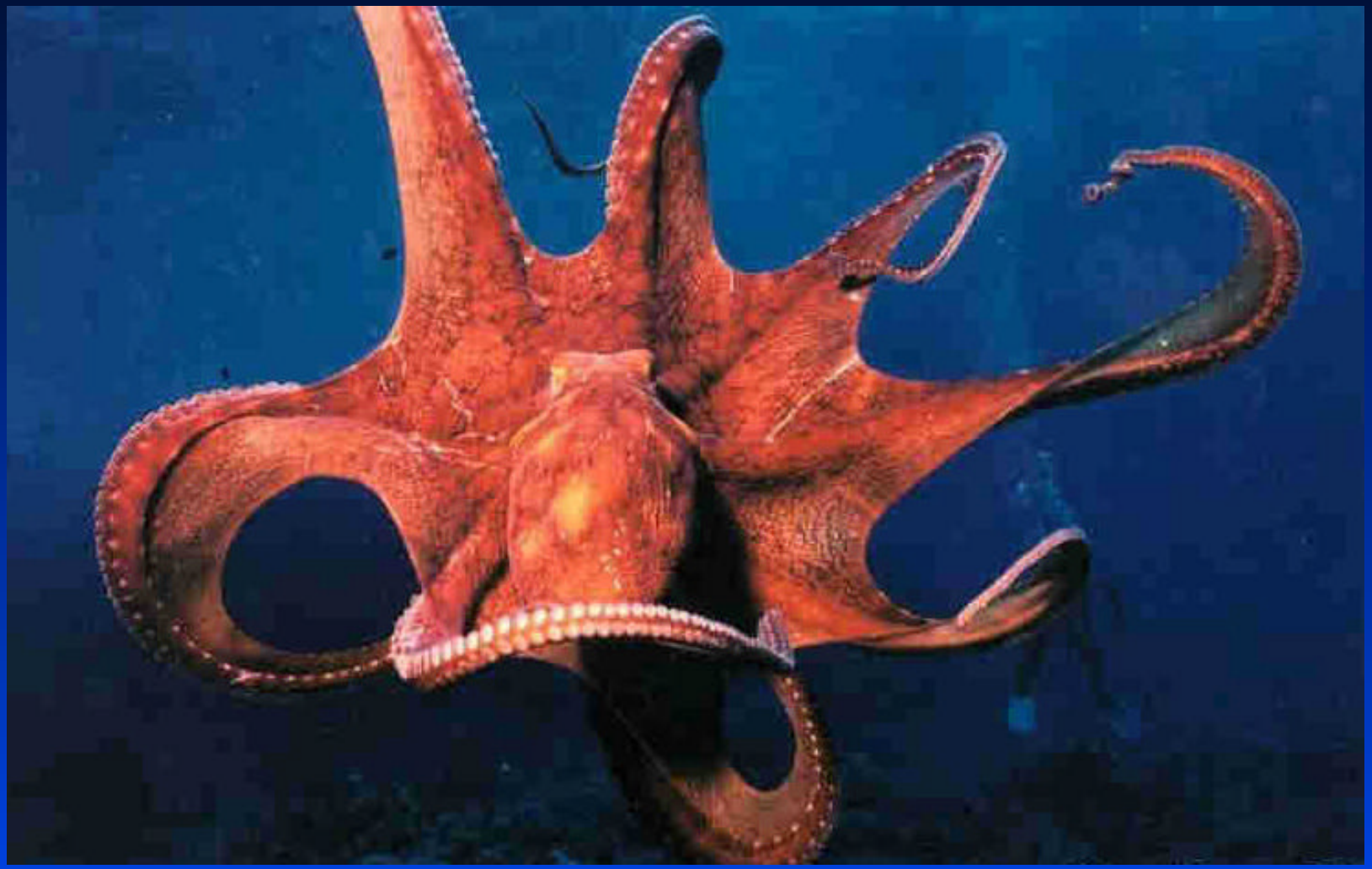
S=0.5-10 wt%; N=0.6-2.6 wt%; O=0.3-4.8 wt%

Metal elements: Ni, V, Fe

Hypothetical polycyclic structures for asphaltene molecules

Speight, J.G.: "A Chemical and Physical Explanation of Incompatibility during Refining Operations," Proc. 4th Intl. Conf. on the Stability and Handling of Liquid Fuels, US Dept. Energy, 169 (1992).

Asphaltene?
Like a sea monster



Differences between asphaltene and wax

	Asphaltene	Wax
Dissolves in heptane:	No	Yes
Crystalline:	No	Yes
Melting point:	No	Yes

Buckley, J.S.: "Asphaltenes: Separating Fact from Fiction," SPE Distinguished Lecture Slides (1998-99).

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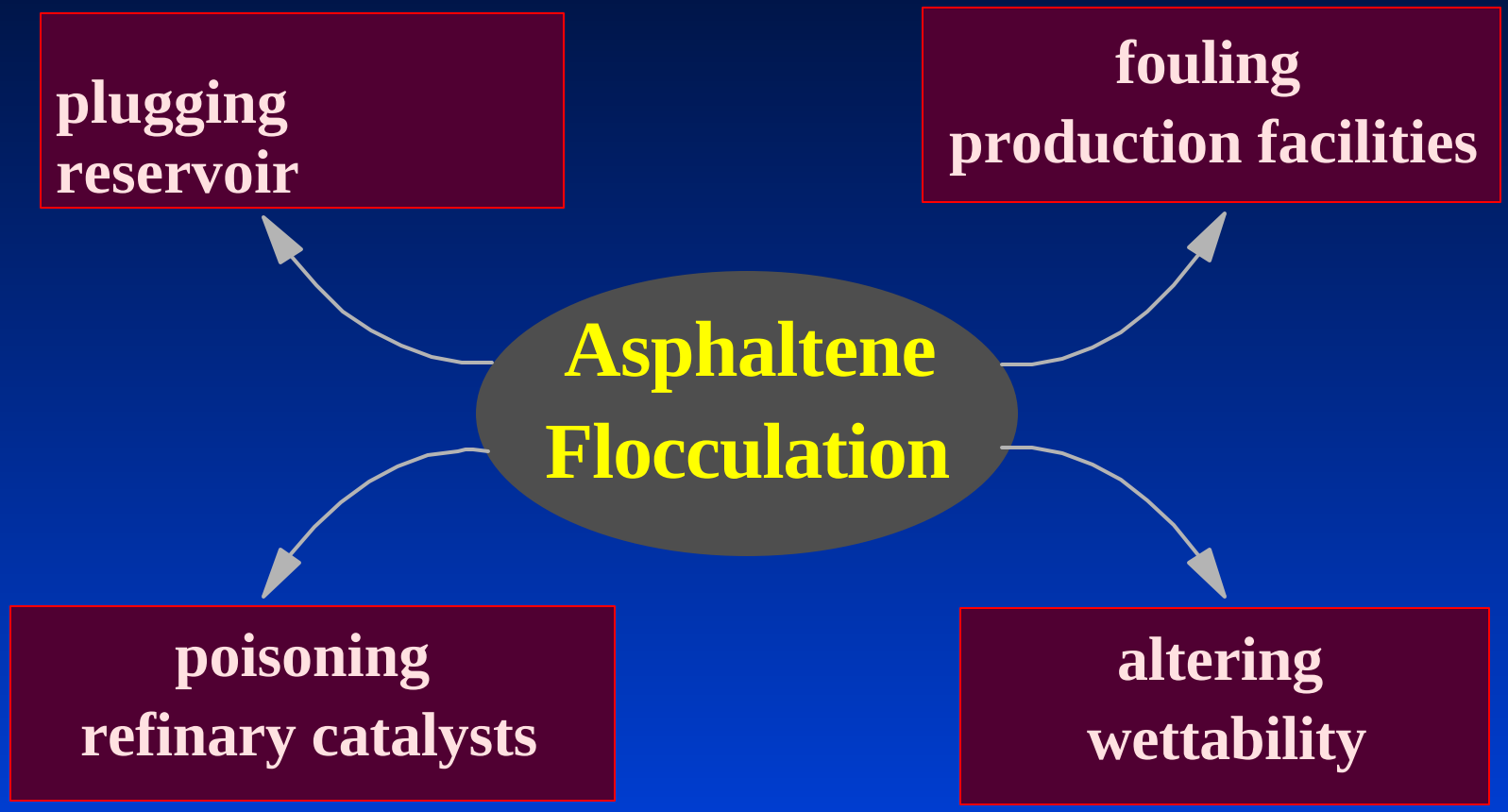
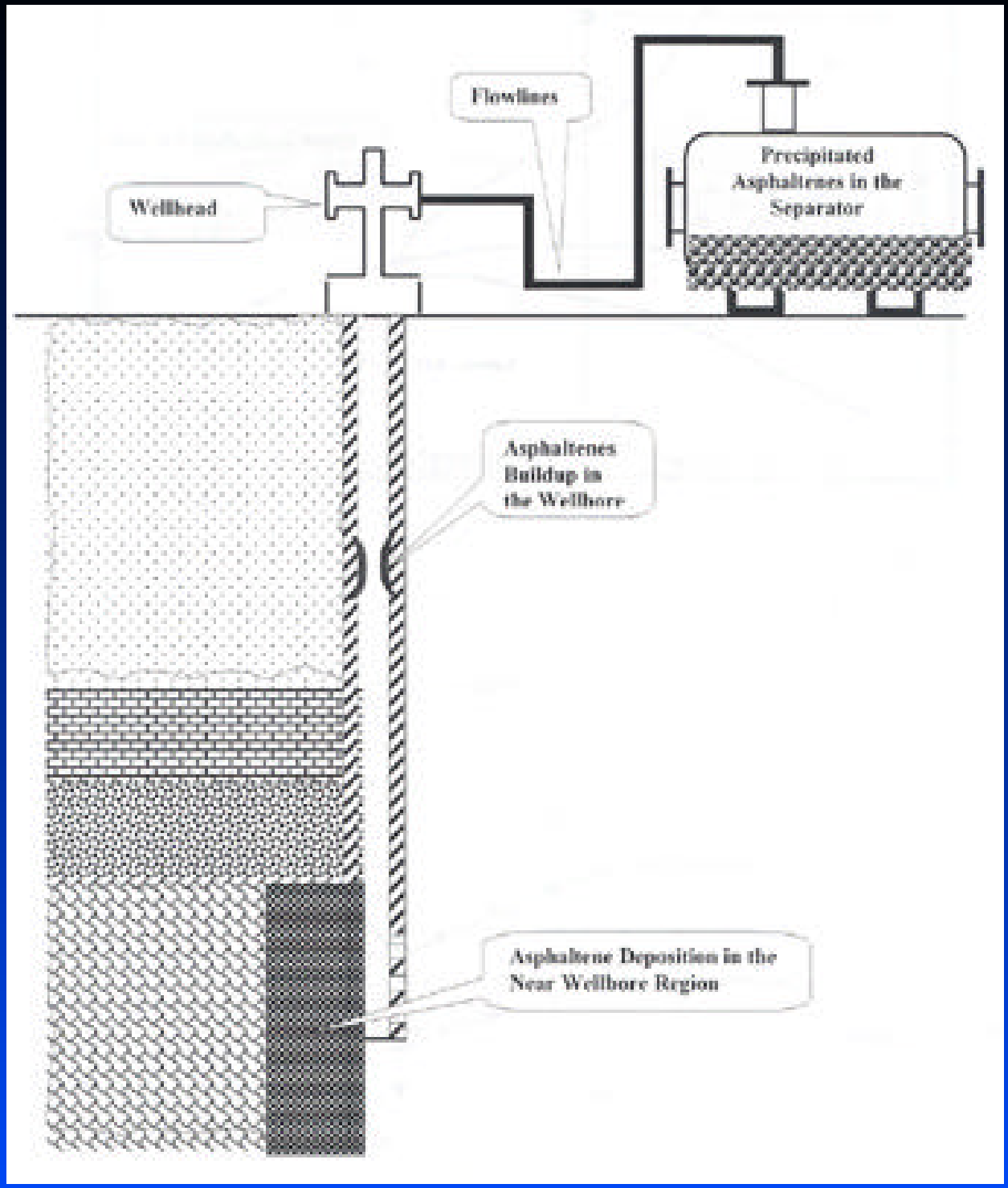
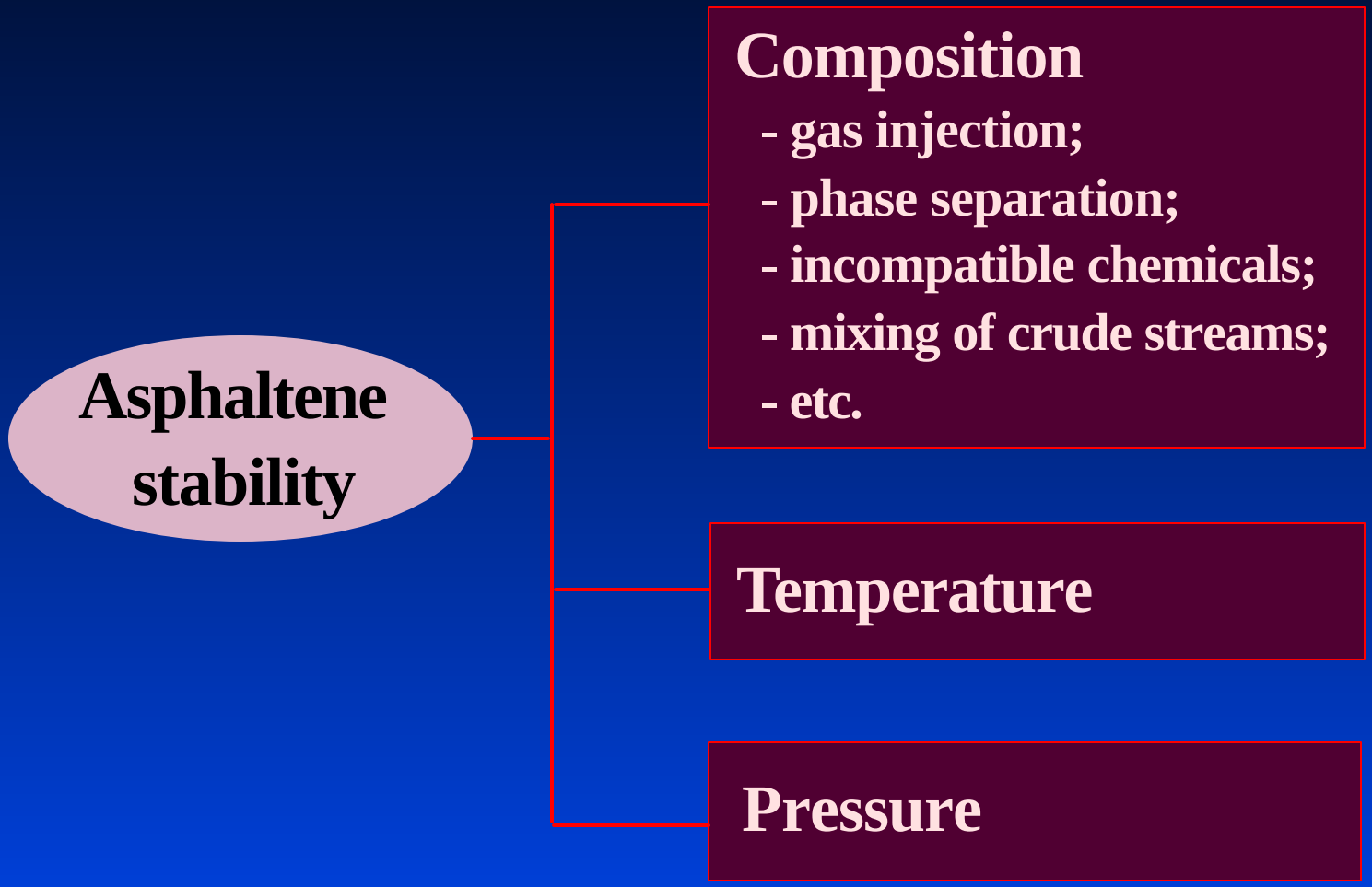
What if asphaltene flocculates ?

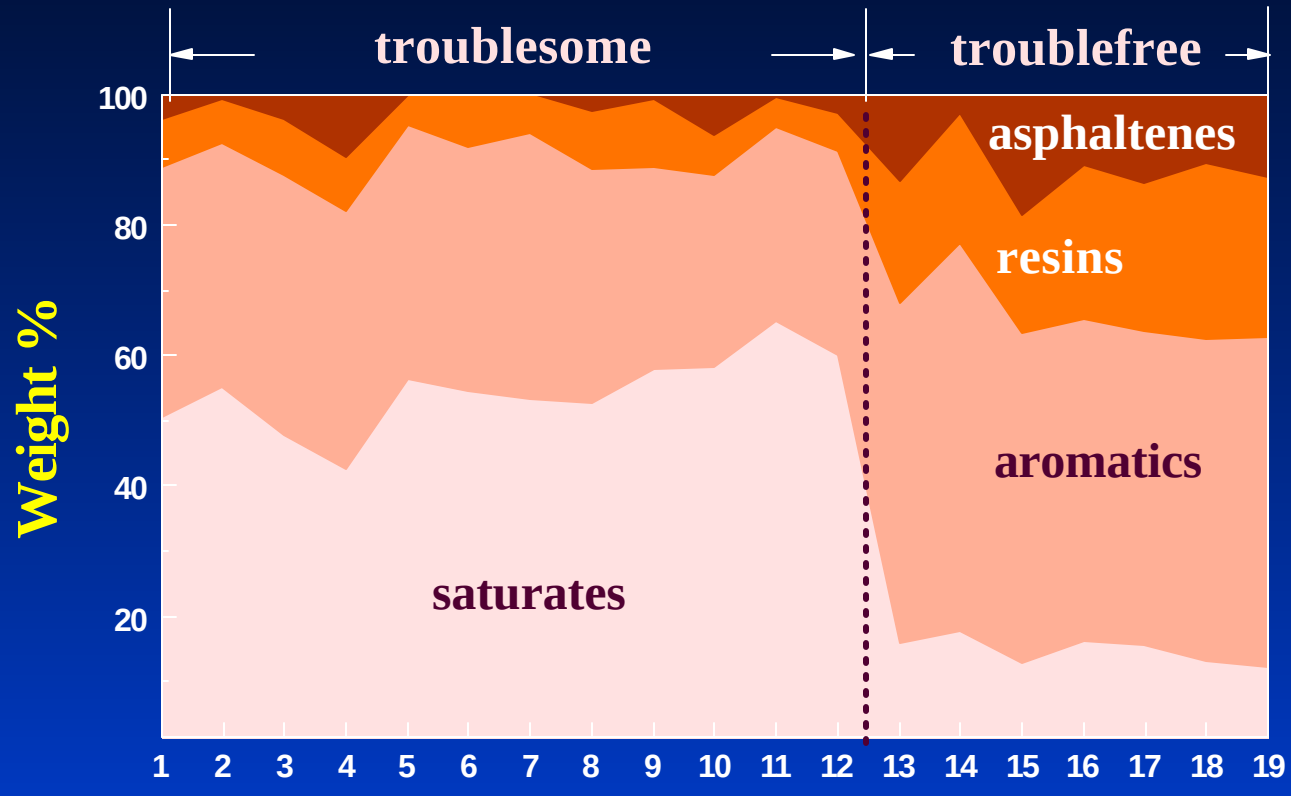



Flowlines
Wellhead
Precipitated Asphaltenes in the Separator
Asphaltenes Buildup in the Wellbore
Asphaltene Deposition in the Near Wellbore Region

Stability is determined by crude oil solvency

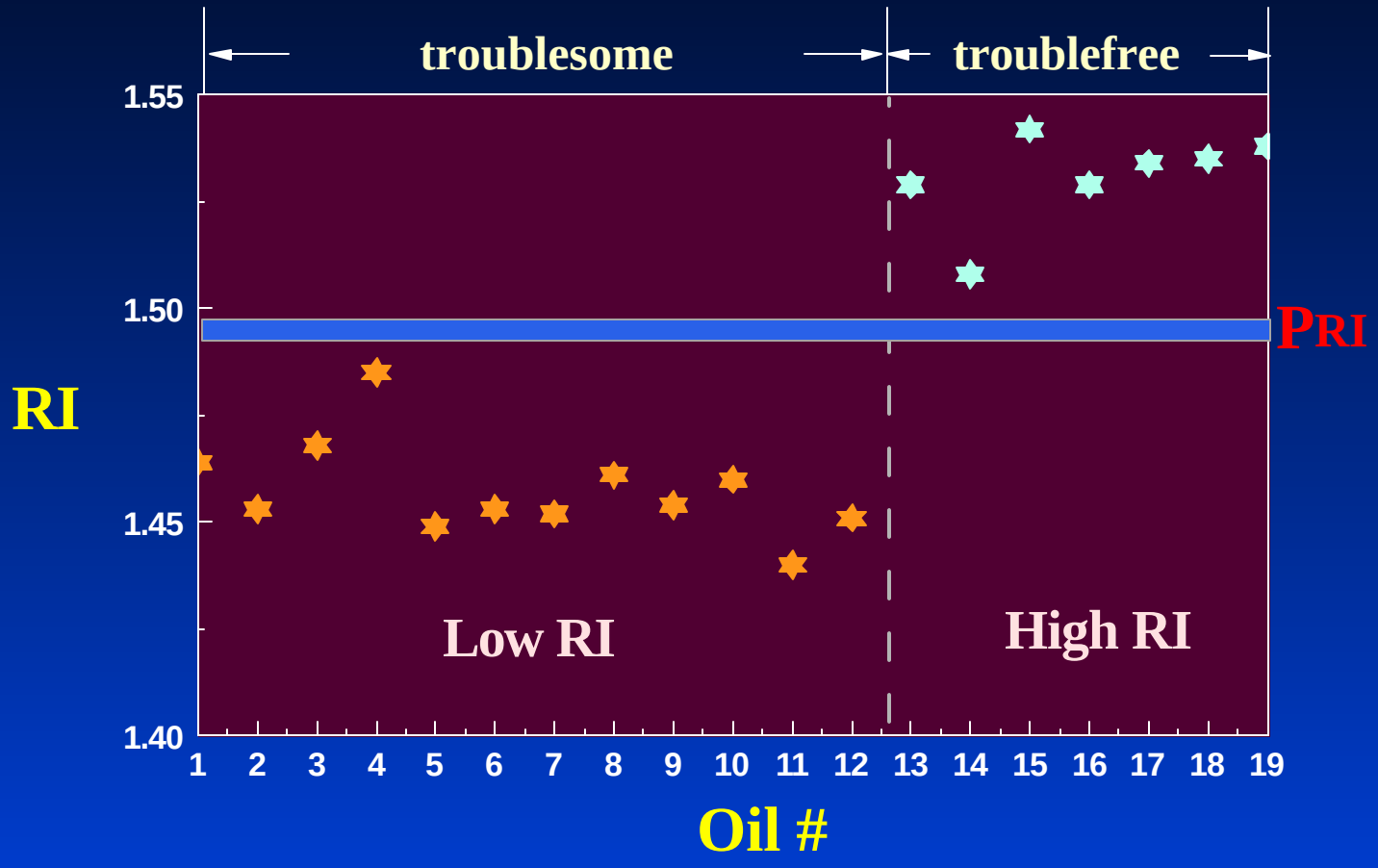


High asphaltene content is not necessary to associate with high risk of trouble



Carbognani, L. and Espidel, J.: "Characterization of Solid Deposits from Production Facilities. Identification of Possible Causes of Deposits Formation," Vision Technologica, Vol. 3, No. 1, 35-42.

Asphaltene trouble is associated with RI



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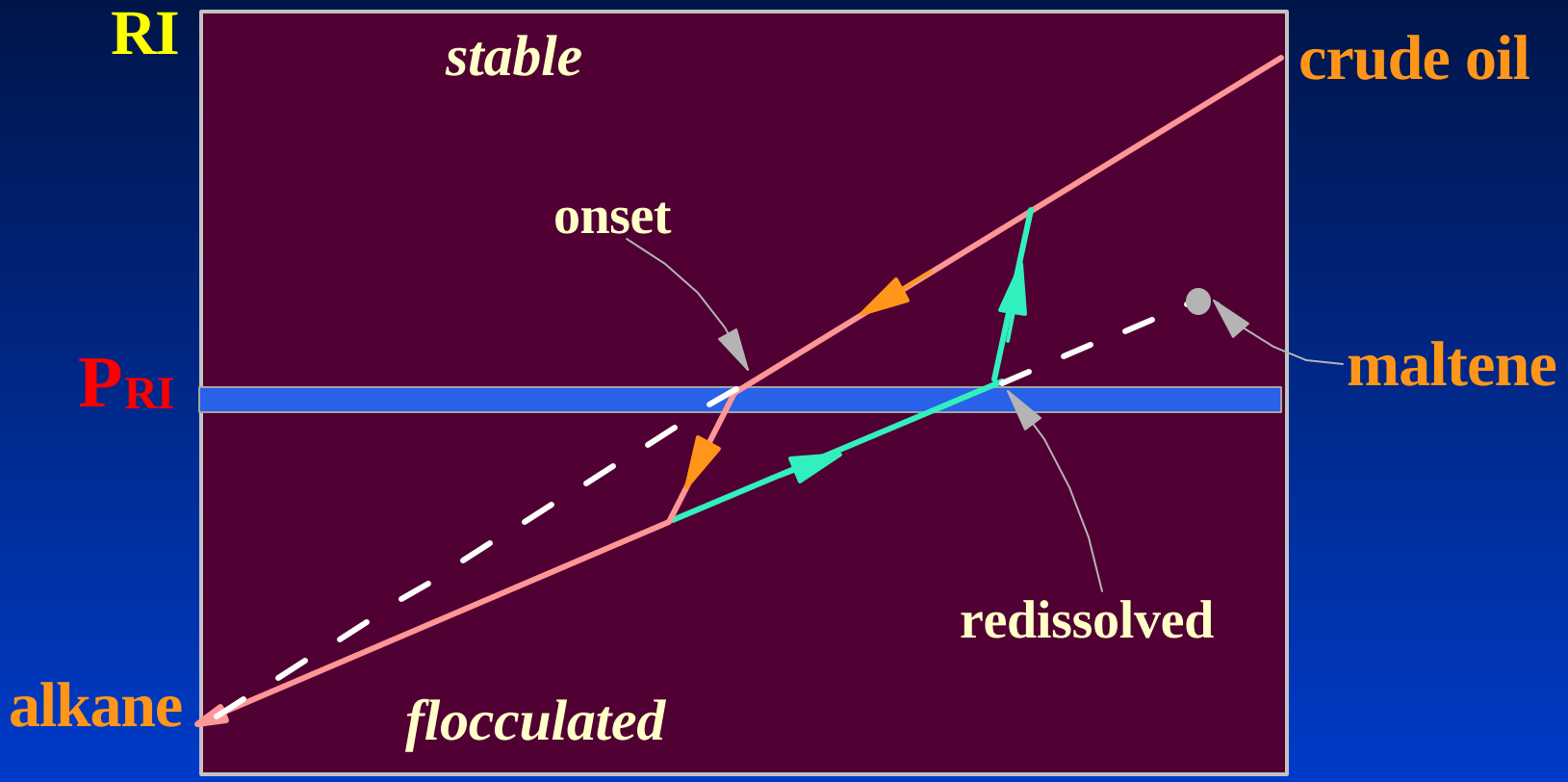
For a given crude/precipitant, flocculation occurs at a critical RI



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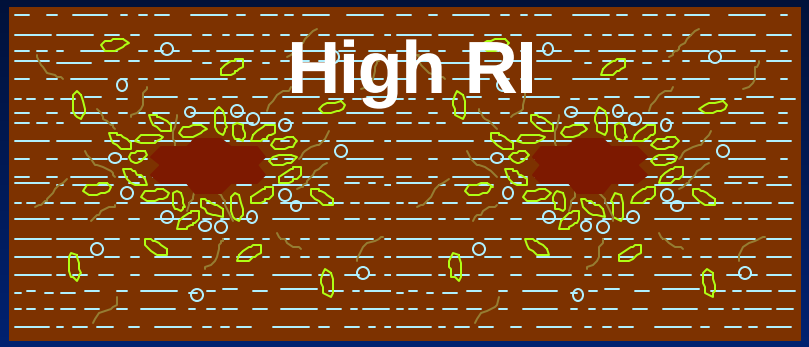
Asphaltene stability varies with solvent RI



In a "good" solvent, asphaltenes are not strongly attracted to one another.

In a "poor" solvent, asphaltenes attractive forces are enhanced.

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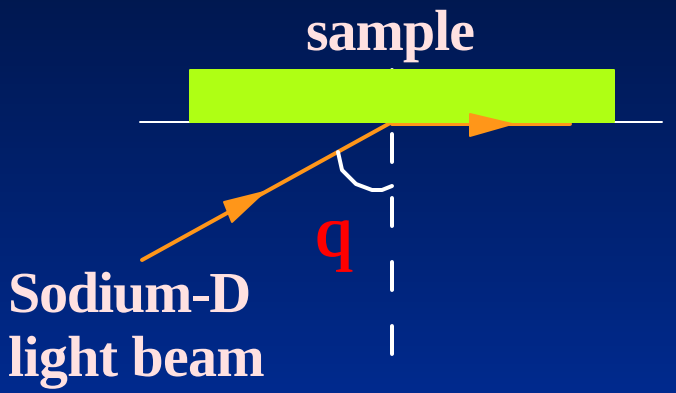
RI measurement



refractometer

RI accuracy = 0.0001
T: 10 ~ 70 °C

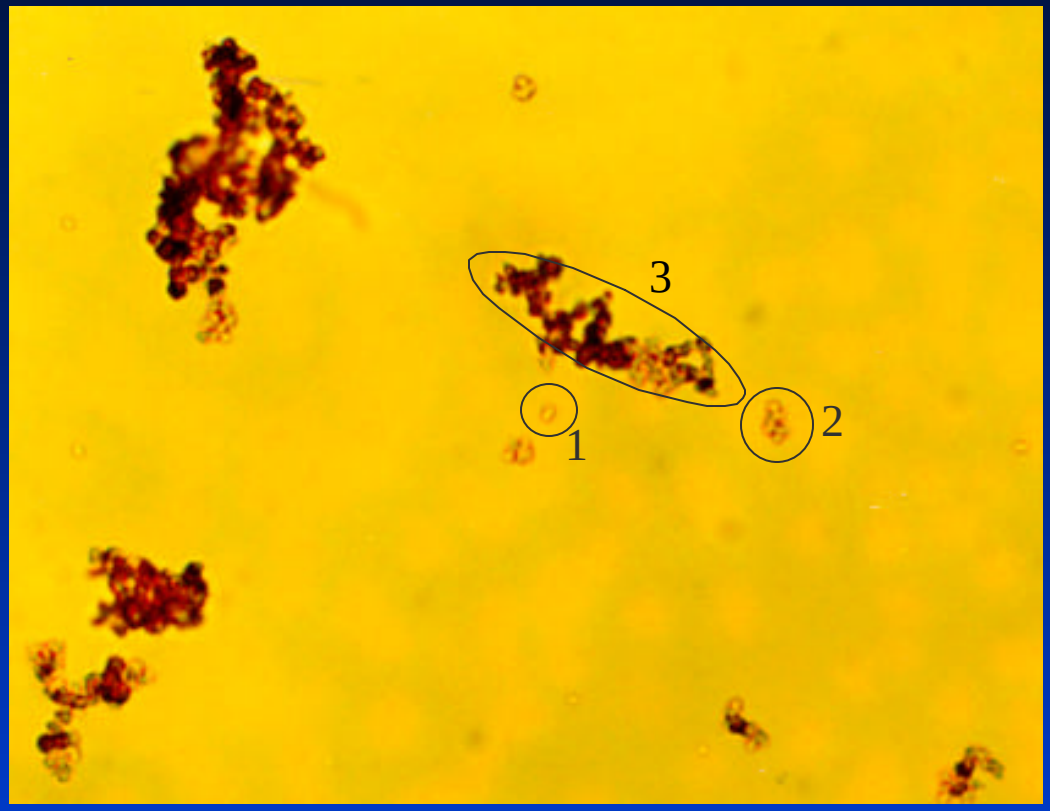
total internal reflection

$$n = \frac{1}{\sin(q)}$$

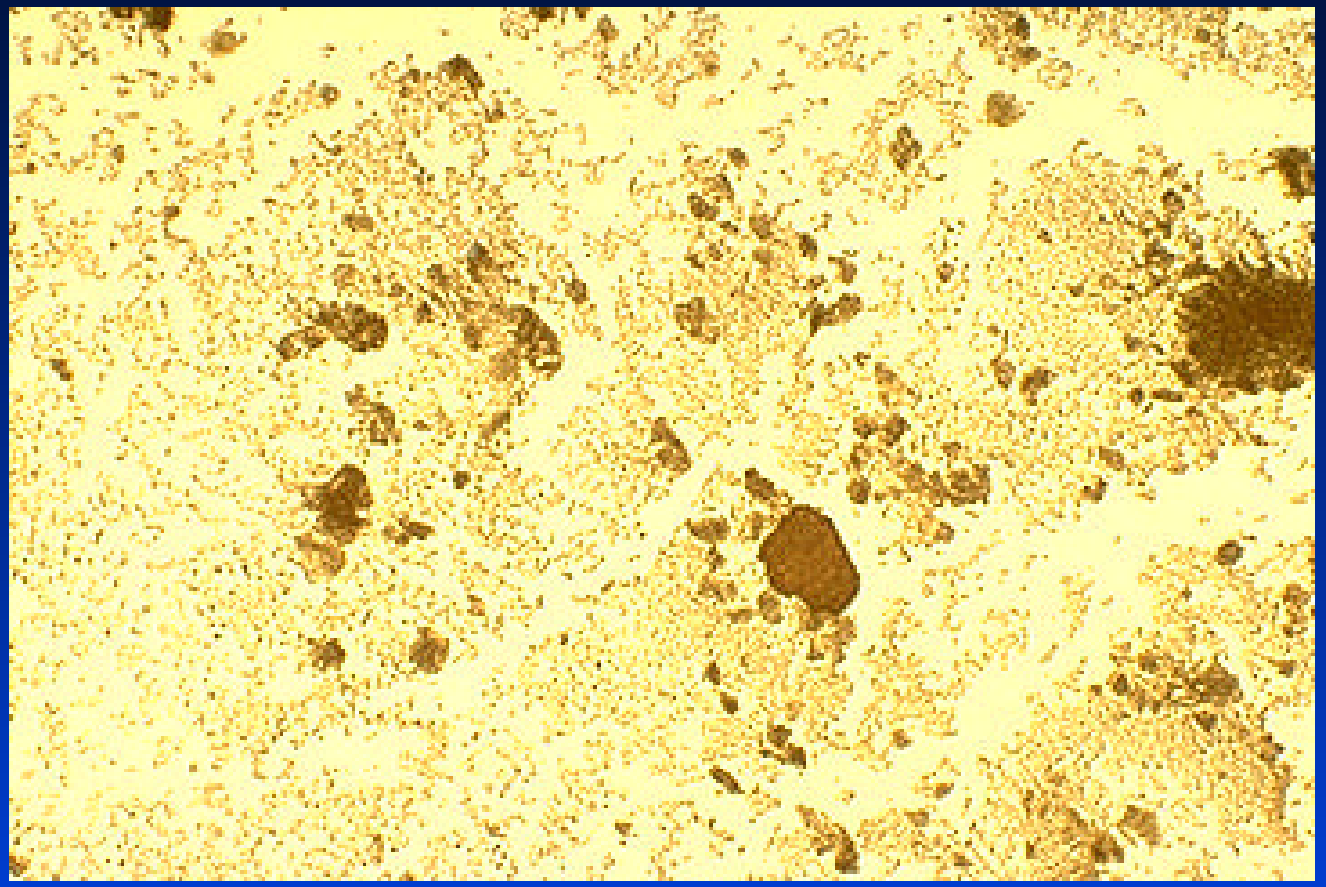
Procedure for onset detection

- Prepare a series of mixtures with varying oil/precipitant ratios in sealed vials
- Aging for 24 hours
- Observe asphaltene precipitation, if any, under microscope
- Once onset is detected, record volume ratio and measure the refractive index (RI) for mixture

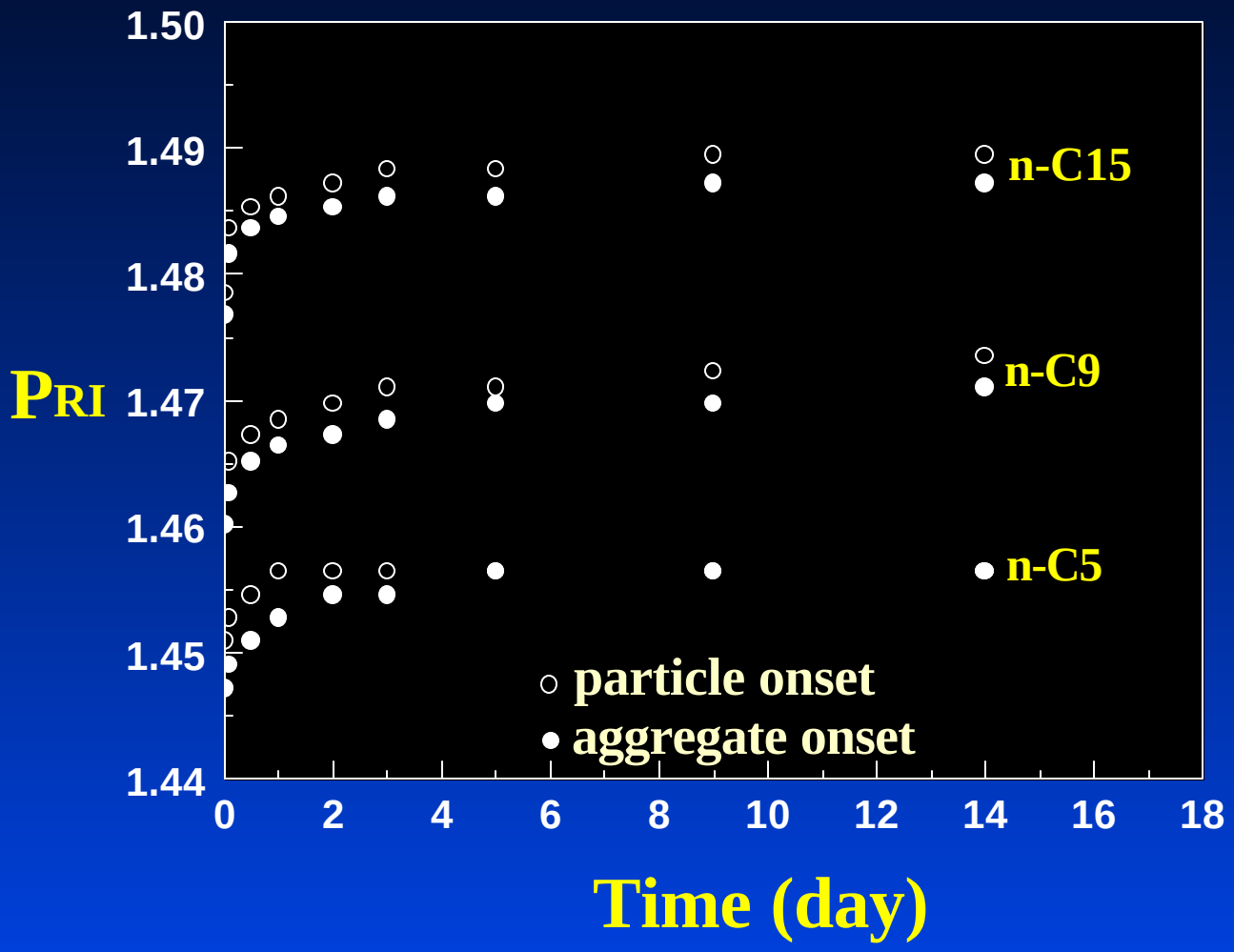
Asphaltene flocculates under microscope (1)



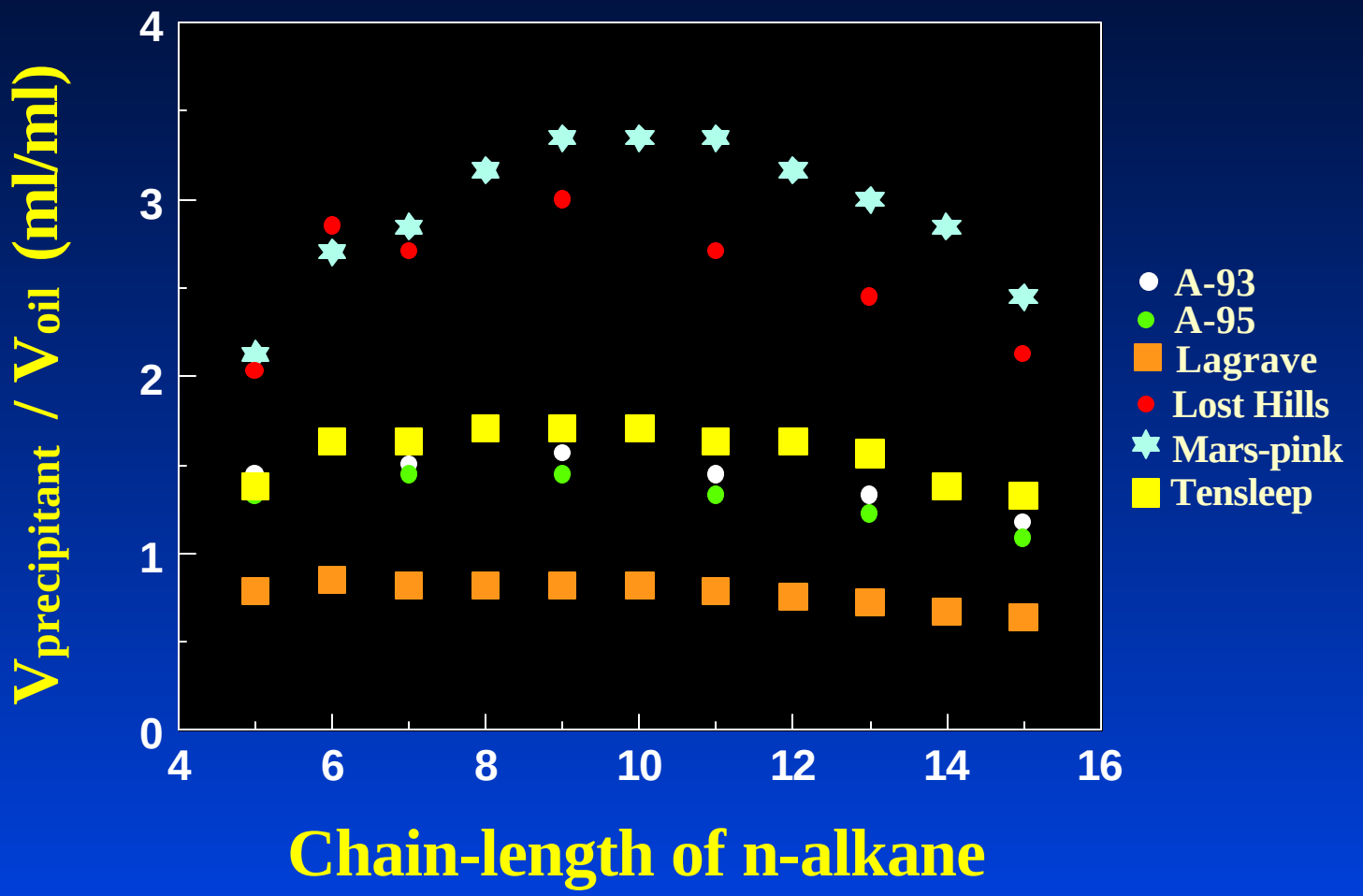
Asphaltene flocculates under microscope (2)



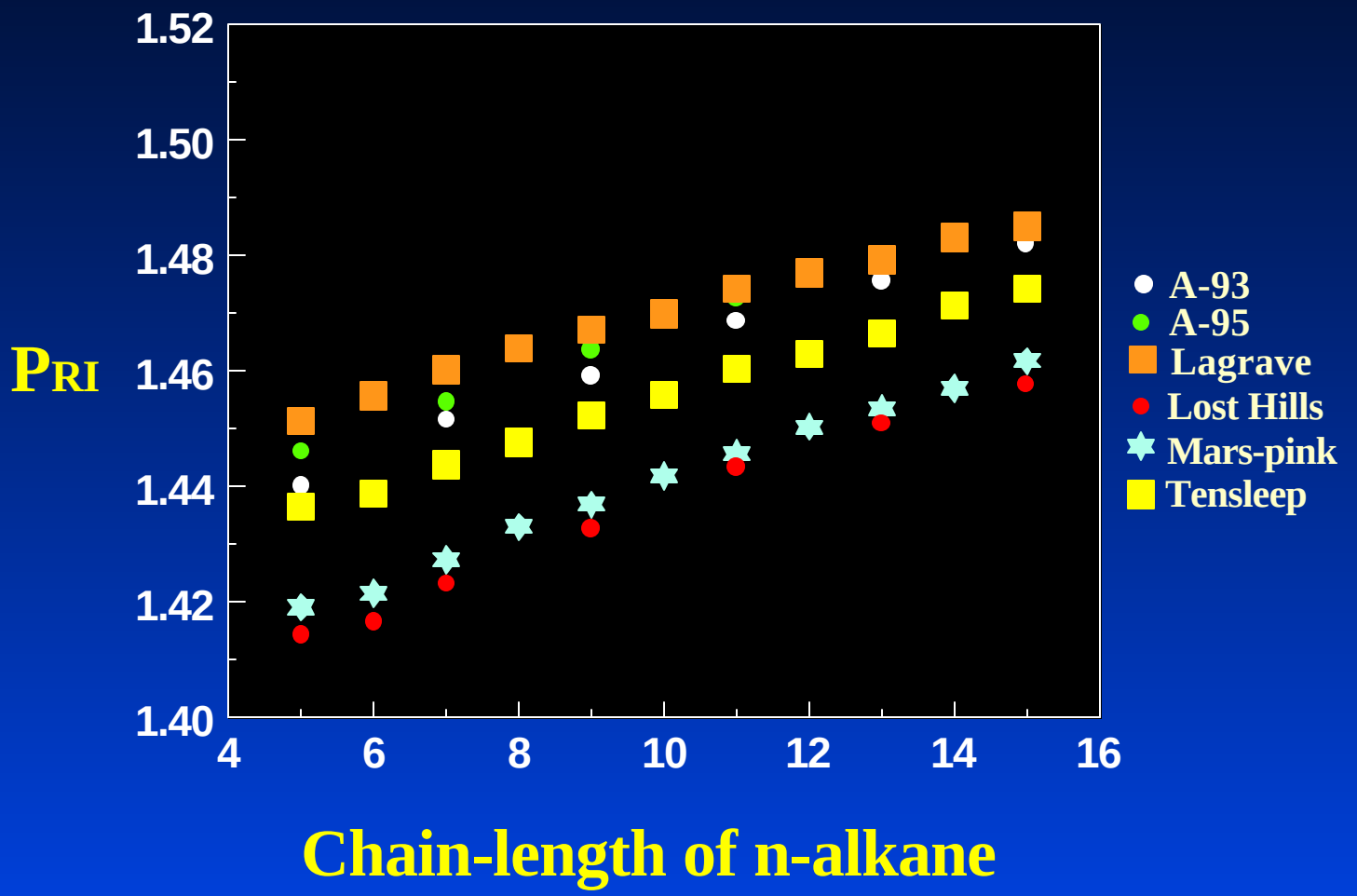
PRI vs. time (Lagrave)



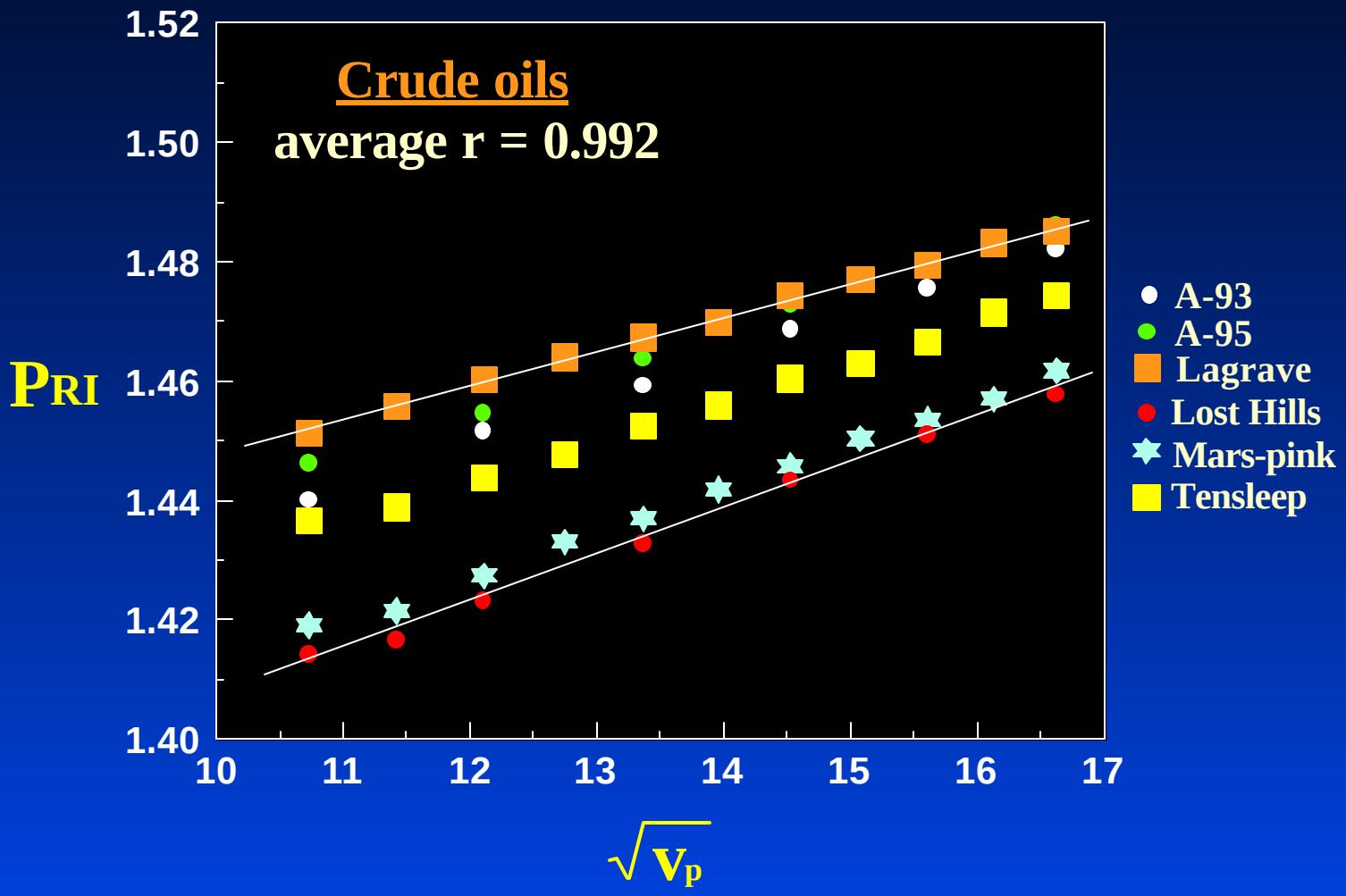
Volume ratios of precipitant to oil at onset



RI at onset (P_{RI}) for crude oils



Simple correlation of P_{RI} vs. precipitant



Conclusions

- Asphaltene molecules are polyaromatics with side chains. They exist in crude oils as monomer and micelles equilibrated to each other. The sizes of asphaltene micelles fall in colloidal range.

- Asphaltene flocculation occurs when oil solvency is reduced. Flocculated asphaltene could have detrimental effects on oil production, transportation and refinary process.

- Refractive index (RI) is a simple, readily measurable parameter for characterizing crude oil solvency with respect to asphaltene stability.