

FIZIKALNA KEMIJA MAKROMOLEKULA

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akad. godina 2025/2026.

prof. dr. sc. Davor Kovačević

oblici nastave:

Predavanja, vježbe (zadaci)

studentski seminari – uvjet za izlazak na ispit

ispit:
pismeni
usmeni

literatura

- S. F. Sun: *Physical Chemistry of Macromolecules: Basic Principles and Issues*, 2. izd., Wiley, New York, 2004.
- A. Y. Grosberg, A. R. Khokhlov: *Giant Molecules*, Academic Press, San Diego, 1997.
- R. J. Young, P. A. Lovell, *Introduction to Polymers*, CRC Press, 2011.
- P. W. Atkins, J. de Paula: *Atkins' Physical Chemistry*, 7. izd., Oxford UP, Oxford, 2002.
- T. Radeva (ur.): *Physical Chemistry of Polyelectrolytes*, M. Dekker, New York, 2001.
- G. Decher i J. B. Schlenoff, *Multilayer Thin Films*, Wiley-VCH, Weinheim, 2003.
- J. Lyklema, *Fundamentals of Interface and Colloid Science, Volume V, Soft Colloids*, Elsevier, Amsterdam, 2005.

Makromolekula

The IUPAC Gold Book **definition** of a **macromolecule** is: "A molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass."



odnos koloidi - makromolekule

slična fizikalna svojstva:

koloidi – agregacija

makromolekule – ponavljajuće jedinice
povezane kovalentnim vezama

makromolekule: polimeri,
polielektroliti, polisaharidi, proteini

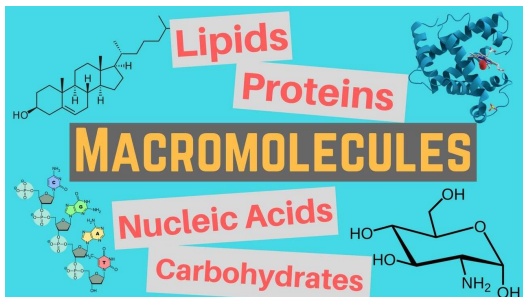
fizikalna kemija makromolekula

makromolekule

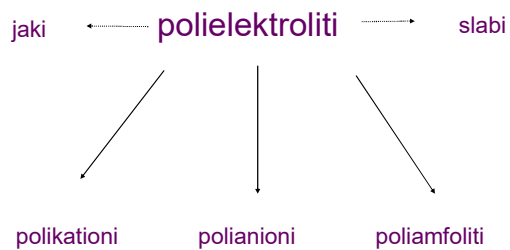
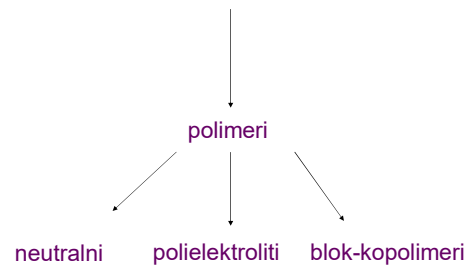
↙
sintetski
polimeri

↘
biološki (prirodni)
polimeri

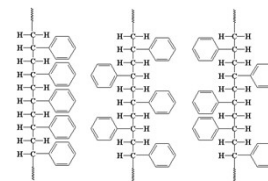
biološke makromolekule



makromolekule



stereokemija polimera



izotaktički sindiotaktički ataktički



Hermann Staudinger
(1881 –1965)

1924.

1953. Nobelova nagrada za kemiju:
"for his discoveries in the field of
macromolecular chemistry"

polimeri



Wallace Hume Carothers
(1896 –1937)

1930.

Paul John Flory



1953.

Nobelova nagrada za kemiju 1974:
"for his fundamental achievements,
both theoretical and experimental,
in the physical chemistry of
macromolecules"

Paul John Flory
(1910 – 1985)

Sinteza polimera

Carothers

Tradicijska podjela
polimerizacijskih reakcija:

- a) kondenzacijska
- b) adicijska

Flory

Nova podjela polimerizacijskih
reakcija:

- a) stupnjevita polimerizacija
(polikondenzacija)
- b) lančana polimerizacija (adicijska)

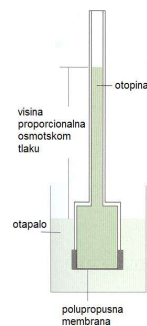
metode određivanja molarne mase

- osmotski tlak
- sedimentacija
- viskoznost

osmotski tlak

$$\Pi = c_B RT$$

$$M_B = \frac{RTm_B}{\Pi V} = \frac{RT}{\Pi} \gamma_B$$

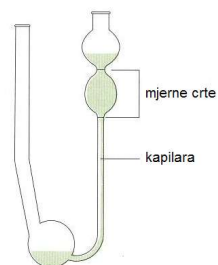


sedimentacija



ultracentrifuga

viskoznost



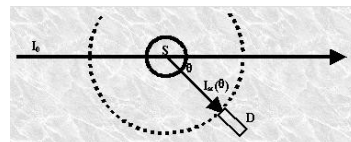
Ostwaldov viskozimetar

metode određivanja veličine makromolekula

- raspršenje svjetlosti
- raspršenje röntgenskih zraka
- raspršenje neutrona
- mikroskopija

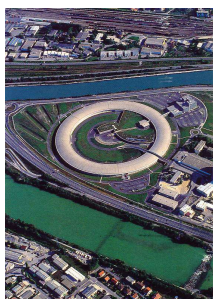
raspršenje svjetlosti

- **D**ynamic **L**ight **S**cattering (**DLS**)
- **S**tatic **L**ight **S**cattering (**SLS**)



SAXS

- **S**mall **A**ngle **X**-ray **S**cattering



European Synchrotron
Radiation Facility (ESRF),
Grenoble, Francuska

SANS

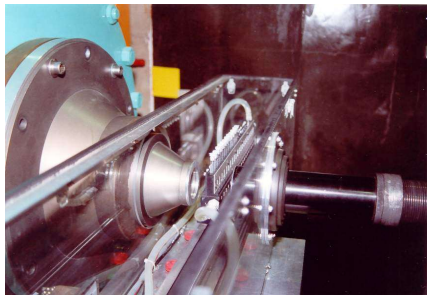
- **S**mall **A**ngles **N**eutron **S**cattering



Institut ILL,
Grenoble,
Francuska

SANS

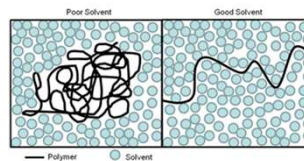
- **S**mall **A**ngles **N**eutron **S**cattering



Makromolekularna termodinamika

strukturni modeli, konfiguracija lanaca; utjecaj strukture i molarne mase na fizikalno-kemijska svojstva makromolekula

elektrostatske interakcije u otopinama makromolekula: problem slobodnog volumena



Flory

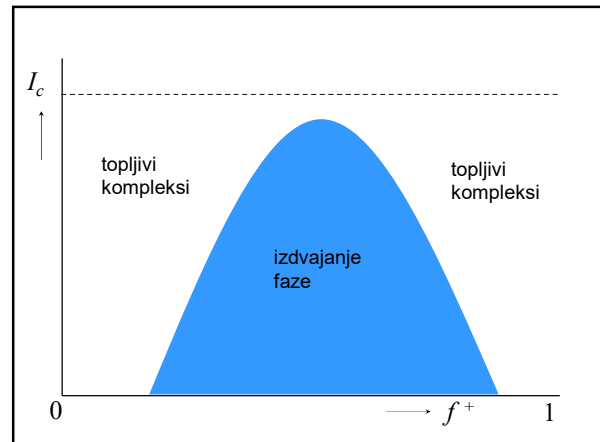
polimeri (polielektroliti) u otopini

topljivost, konformacija, nastajanje
polielektrolitnih kompleksa

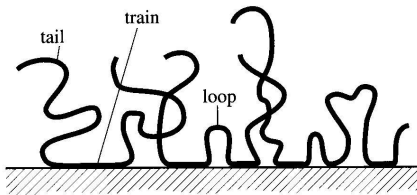
- elektrostatske interakcije
- topljivi kompleksi
- izdvajanje faze (phase separation)

istraživali Voorn, Bungeberg de Jong i
Michaels

u *Colloid Science*, H. R. Kruyt, Ed. (Elsevier Publishing
Company, Amsterdam, 1949) vol. II, pp. 335-384



polimeri (polielektroliti) na površini; adsorpcija polimera

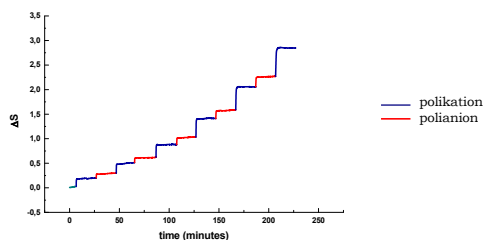


adsorpcija polimera, kinetika adsorpcije,
polielektrolitni višeslojevi, polielektrolitne četke

višesloj (multilayer)?

- nastaju naizmjeničnom adsorpcijom polikationa i polianiona na čvrstu površinu
- najčešća metoda naizmjenično uranjanje u otopinu polielektrolita
- intenzivno istraživano posljednjih petnaestak godina (preko 100 radova godišnje)
- istražuju se uglavnom jaki polielektroliti

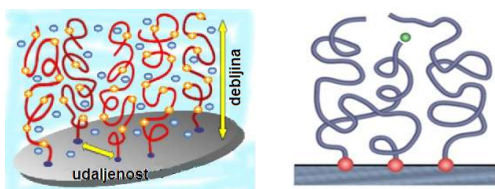
polielektrolitni višeslojevi (*Polyelectrolyte Multilayers*)



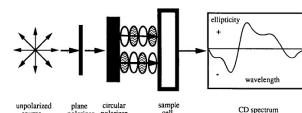
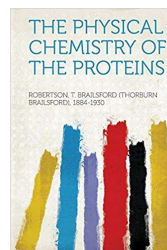
primjena

- modifikacija površine
- inkapsulacija (encapsulation)
- šuplje sfere (hollow spheres)
- drug delivery

polielektrolitne "četke" (*Polyelectrolyte Brushes*)



Fizikalna kemija proteina



Cirkularni dikroizam (CD)