

## FIZIKALNA KEMIJA MAKROMOLEKULA

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## oblici nastave:

Predavanja, vježbe (zadaće)

studentski seminari – uvjet za izlazak na ispit

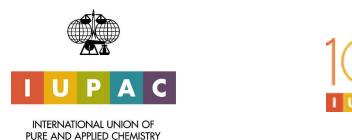
ispit:  
pismeni  
usmeni

## 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.
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- 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

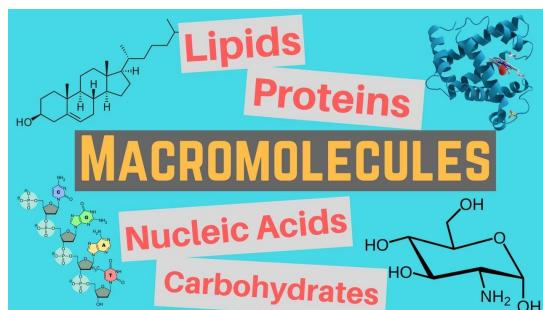
## fizikalna kemija makromolekula

### makromolekule

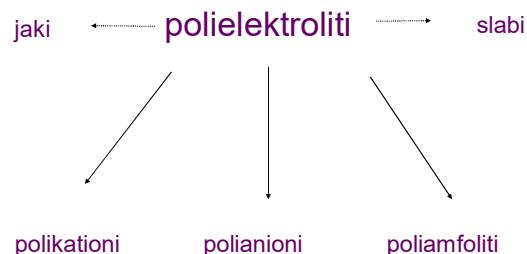
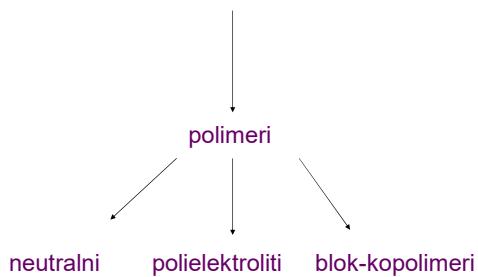
sintetski  
polimeri

biološki (prirodni)  
polimeri

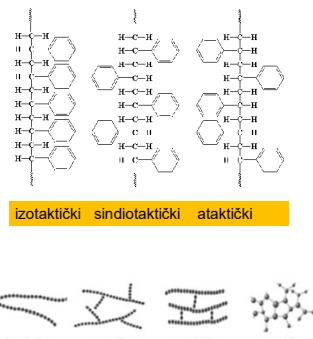
## biološke makromolekule



## makromolekule



## stereokemija polimera



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)

## 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

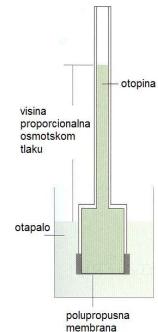
Nova podjela polimerizacijskih  
reakcija:  
a) stupnjevita polimerizacija  
(polikondenzacija)  
b) lančana polimerizacija (adicijska)

## metode određivanja molarne mase

- osmotski tlak
- sedimentacija
- viskoznost

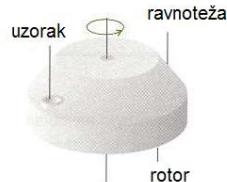
$$\Pi = c_B RT$$

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



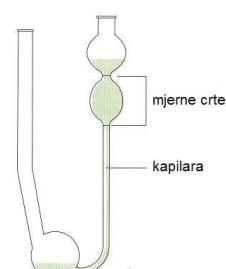
## osmotski tlak

## sedimentacija



ultracentrifuga

## viskoznost



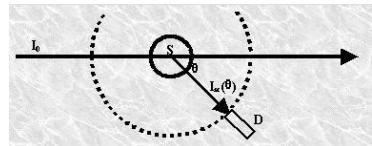
Ostwaldov viskozimetar

## metode određivanja veličine makromolekula

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

## raspršenje svjetlosti

- Dynamic Light Scattering (**DLS**)
- Static Light Scattering (**SLS**)



## SAXS

- Small Angle X-ray Scattering



European Synchotron  
Radiation Facility (ESRF),  
Grenoble, Francuska

## SANS

- Small Angles Neutron Scattering



Institut ILL,  
Grenoble,  
Francuska

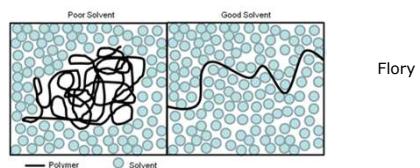
## SANS

- Small Angles Neutron Scattering



## Makromolekularna termodinamika

strukturni modeli, konfiguracija lanaca; utjecaj strukture i molarne mase na fizikalno-kemijska svojstva makromolekula  
elektrostatske interakcije u otopinama makromolekula: problem slobodnog volumena

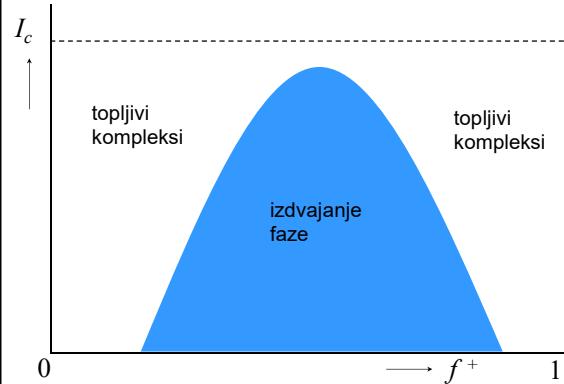


## polimeri (polielektroliti) u otopini

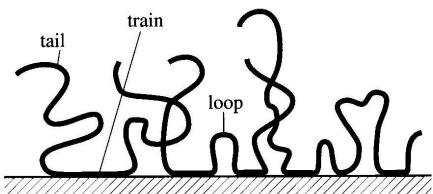
topljivost, konformacija, nastajanje  
polielektrolitnih kompleksa

- 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

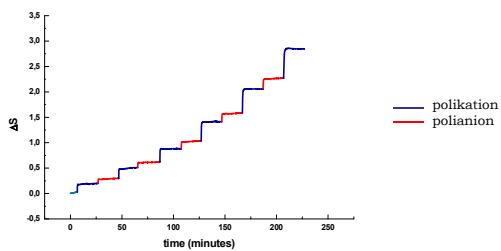


adsorpcija polimera, kinetika adsorpcije,  
polielektrolitni višeslojevi, polielektrolitne četke

## višesloj (multilayer)?

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

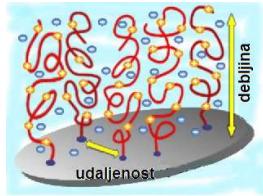
## polielektrolitni višeslojevi (*Polyelectrolyte Multilayers*)



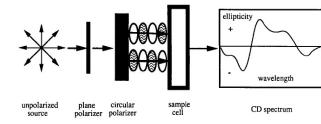
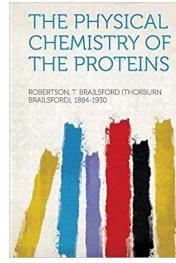
## primjena

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

## polielektrolitne "četke" (*Polyelectrolyte Brushes*)



## Fizikalna kemija proteina



Cirkularni dikroizam (CD)