



POZNAN UNIVERSITY OF TECHNOLOGY  
Poland



# **Inverse liquid chromatography in the study of physicochemical properties of hydroxyapatite-polymer monolithic columns**

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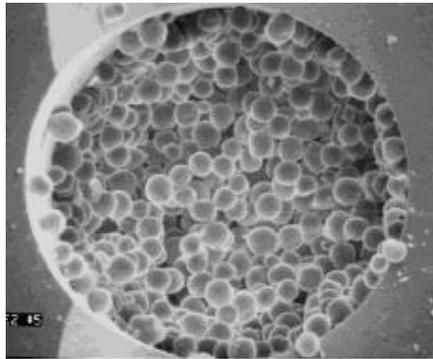
Adam Voelkel



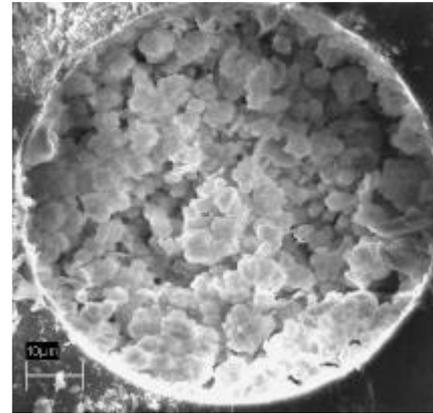
# INTRODUCTION

# Monolithic bed

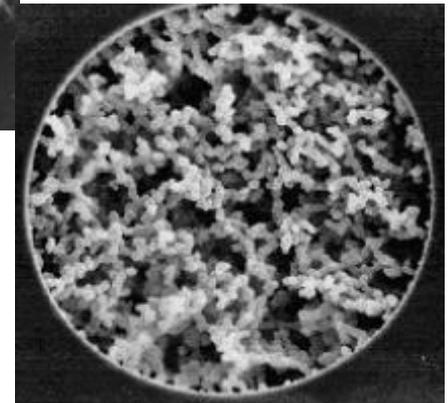
- Continuous homogeneous, porous structure, in the form of a backbone, prepared by polymerisation or other consolidation (sintering, deposition, compression) of the material inside the capillary.



particle-packed columns



monolith



# Monolithic materials

- HPLC separation, purification.
- Sorbents for sample preparation (solid phase extraction - SPE).
- High surface area and high stability.
- Highly permeable to liquid flow.
- High efficiencies with low back pressures.
- Reduced run times with high flow rate.



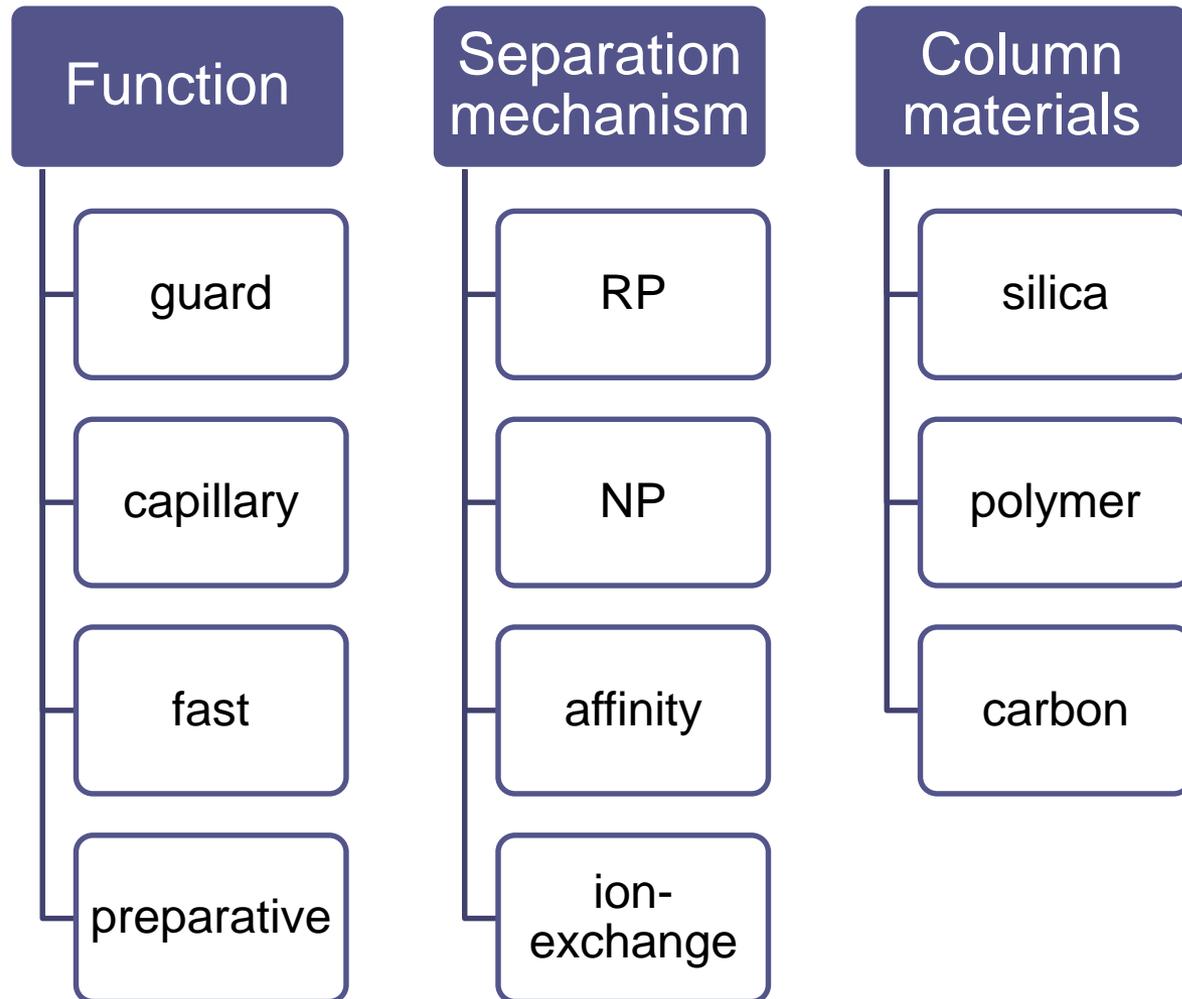
<https://www.thermofisher.com>

<http://www.glsciences.com>

<http://www.lifescience.ca>

<https://www.phenomenex.com/>

# Classification of monolithic HPLC columns





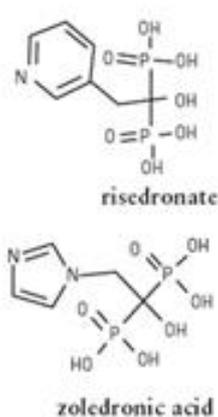
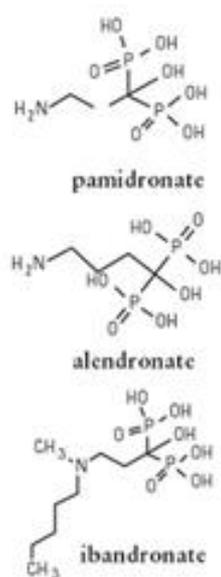
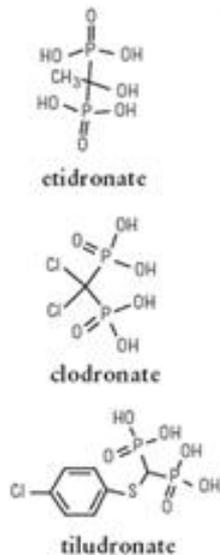
# **MATERIALS AND METHODS**

# Hydroxyapatite-polymer monolithic material

Investigation of the **interactions** between  
drugs and hydroxyapatite

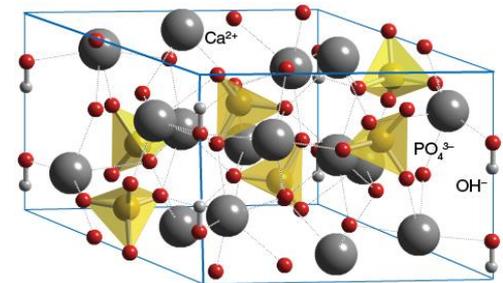
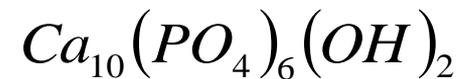
## Bisphosphonates

- high affinity for hydroxyapatite
- bind to calcium



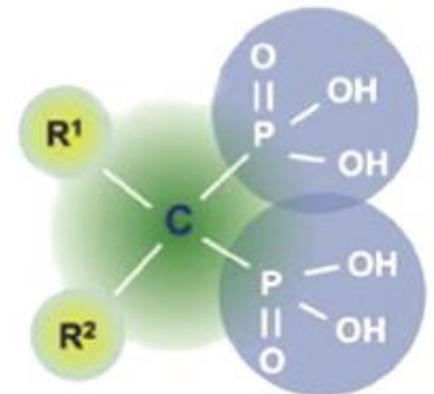
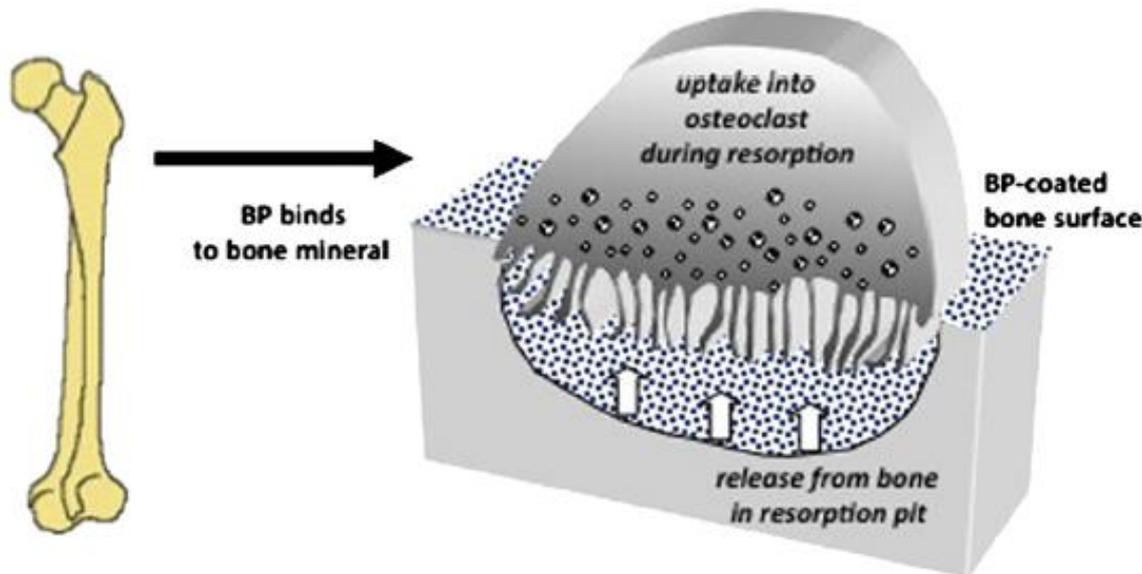
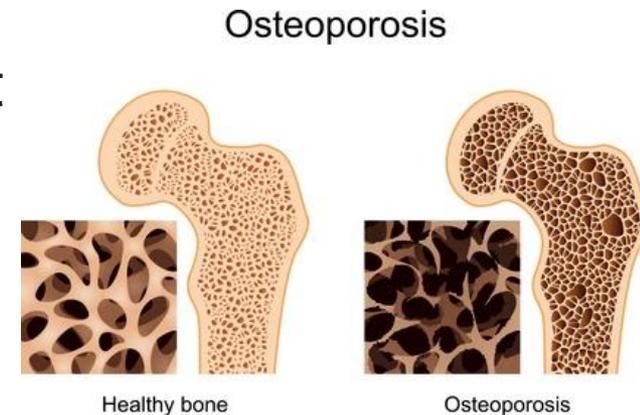
## Hydroxyapatite (HA)

- major component and essential ingredient of bone



# Bisphosphonates

- Bisphosphonates (BPs) inhibit bone resorption and are widely used for the treatment of bone diseases, including osteoporosis.



# Bisphosphonates

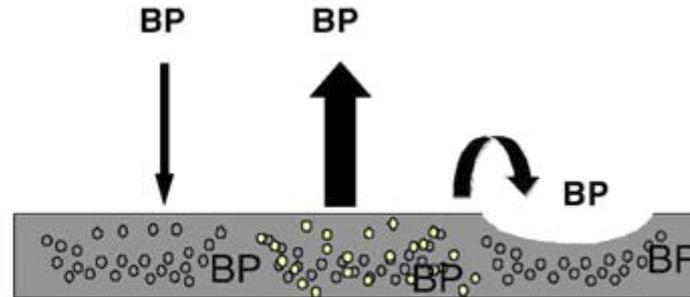
- The differences among BPs in binding to hydroxyapatite are associated with the long duration of action.
- It was proved, that BPs can be found in plasma and urine many months after dosing.
- This means, that BPs must be present in the circulation and available for reuptake into bone for prolonged periods.

# Bisphosphonates

## Bisphosphonate Uptake and Detachment from Bone Surfaces

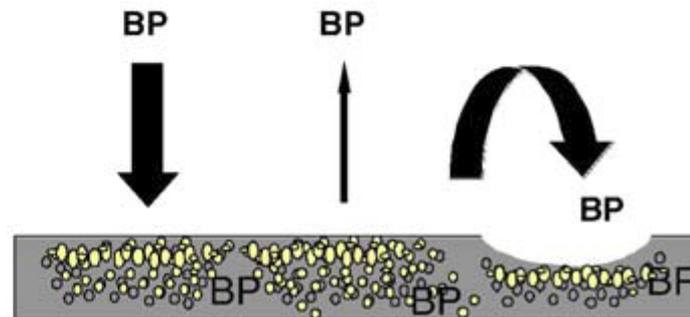
### Lower Affinity BP

- Weaker uptake
- Higher desorption
- Lower re-attachment
- More diffusion in bone



### Higher Affinity BP

- Avid uptake
- Lower desorption
- Higher re-attachment
- Less diffusion in bone



# Bisphosphonates

- Bisphosphonates cause several complications.
- Oral ingestion is associated with rhinitis gastritis or esophagus and abdominal pain.
- Additionally BPS cause disease known as bisphosphonate-related osteonecrosis of the jaw (BRONJ).

# Monolithic materials preparation

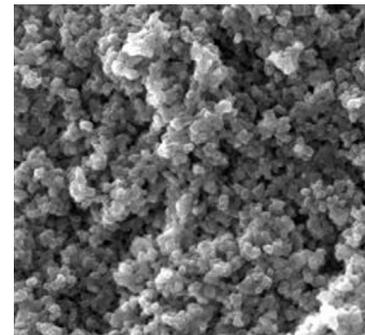
- Poly(2-hydroxyethyl methacrylate-co-ethylene dimethacrylate)

## HEMA / EDMA/ Hydroxyapatite (**HEH**)

	Monomer [%]	Porogen [%]	HA [%]
HEH0	30	70	0
HEH1	27	70	3
HEH2	24	70	6
HEH3	21	70	9
HEH4	18	70	12

Porogens: Dodecanol, cyclohexanol, toluene

Material	BET [m <sup>2</sup> /g]	Pore size [Å]
HEH0	4.41	74.5
HEH3	35.72	119.4



# Physicochemical characterisation of HEH material

## Inverse Liquid Chromatography

- Dionex Ultimate 3000 LC; RI, UV-VIS detectors,
- The stainless steel column (2.1mm i.d. x 100mm) filled with HEH,
- Mobile phase: methanol, dichloromethane, acetonitrile.

### TEST SOLUTES:

Cyclohexanone, 1,4-dioxane, Aniline, Pyridine, Benzotrile, THF, DMF, Cyclohexanole, 1,3-Propanediol, Butanone, Diethyl ether, Propylamine, Acetofenone, 1,3-diaminopropane, Acetic acid, Ethyl acetate, Geraniol, Phenol, Ibuprofen, Acetonitrile, Propan-1-ol.



# Inverse Liquid Chromatography

Linear solvation energy relationship - **Abraham model**

$$\log SP = eE + sS + aA + bB + vV + c$$

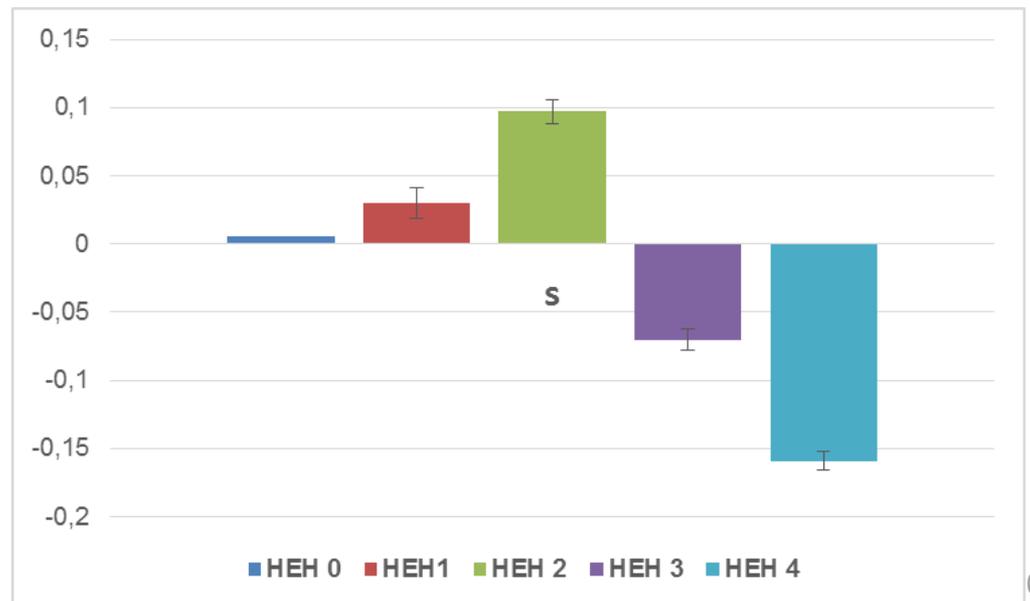
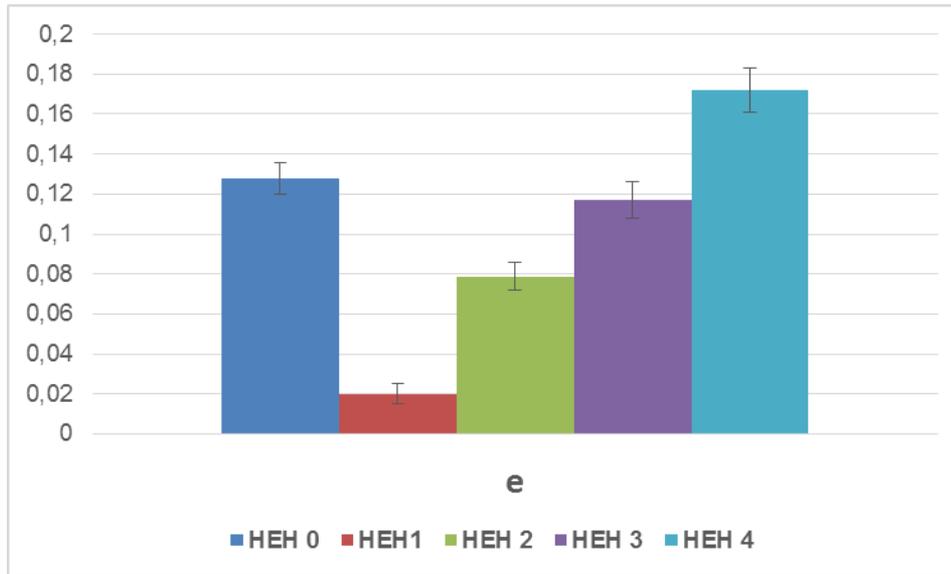
**SP** - is some free energy related solute property such as a distribution constant, retention factor, specific retention volume.

- **e** - dispersion and induction interactions,
- **s** - dipole-type interactions,
- **a** - hydrogen-bond basicity,
- **b** - hydrogen-bond acidity,
- **v** - a measure of the difference in cavity formation in the two condensed phases together with any residual dispersion interactions, that are not selfcanceling.

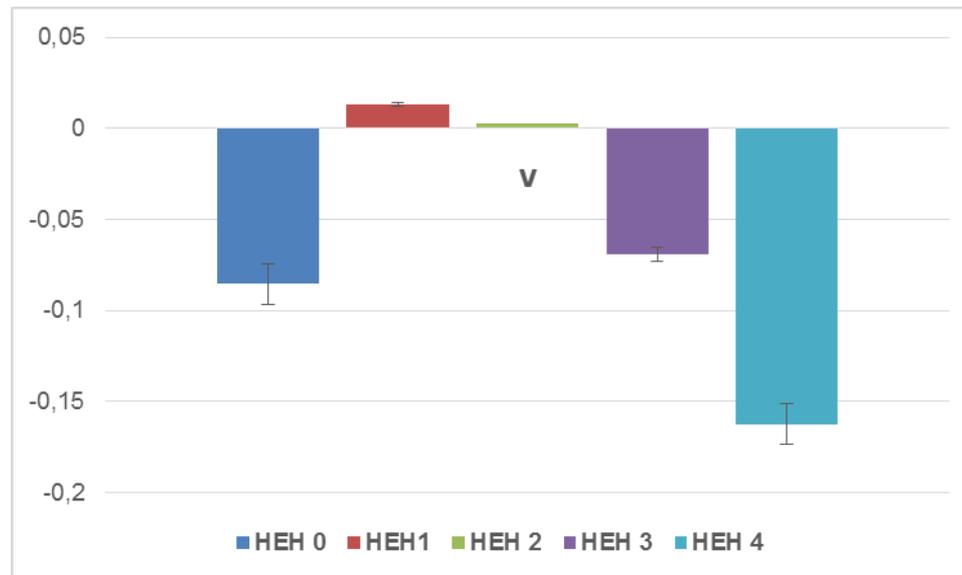
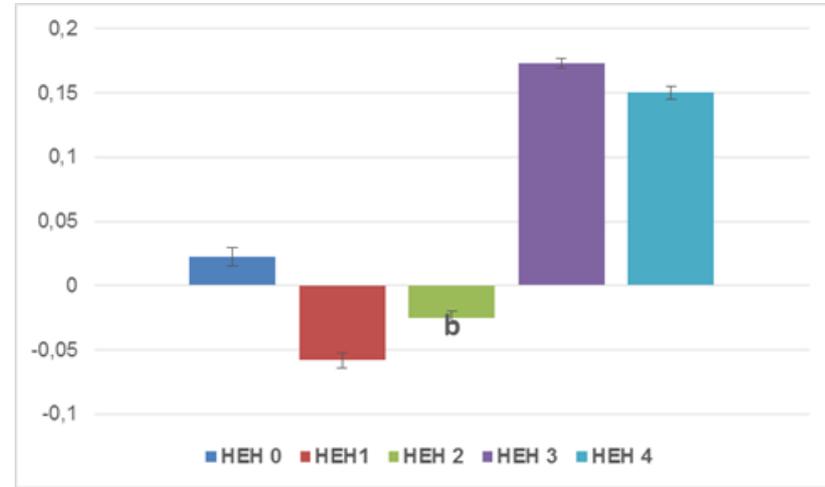
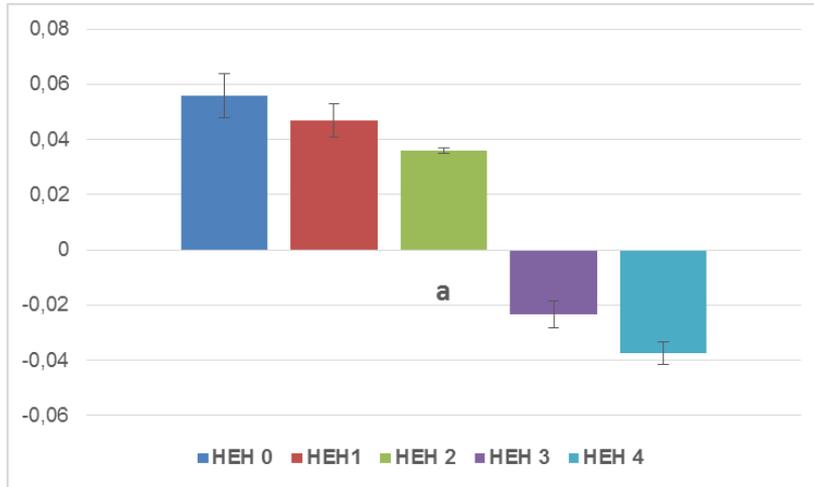


# RESULTS

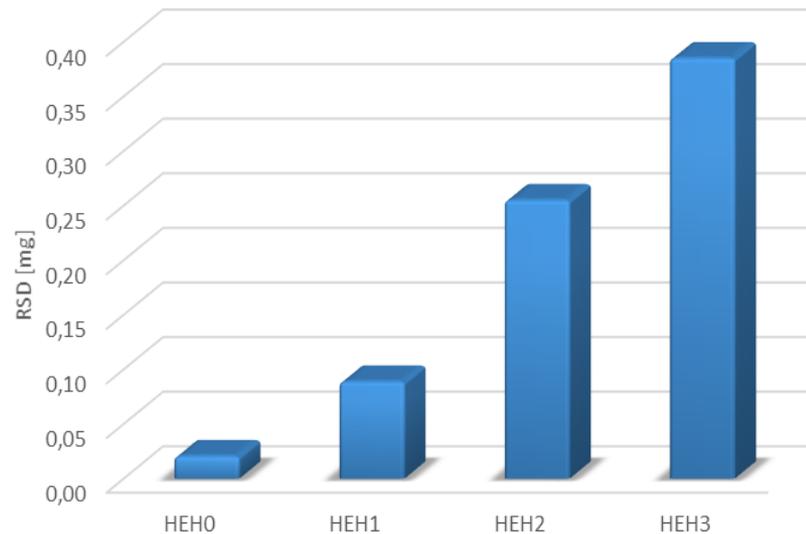
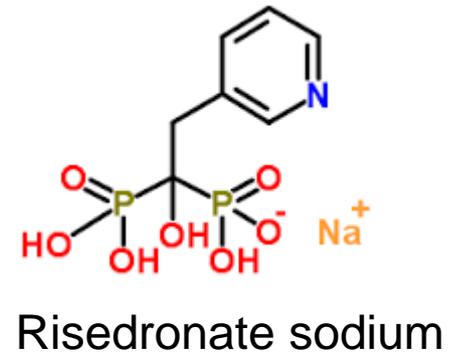
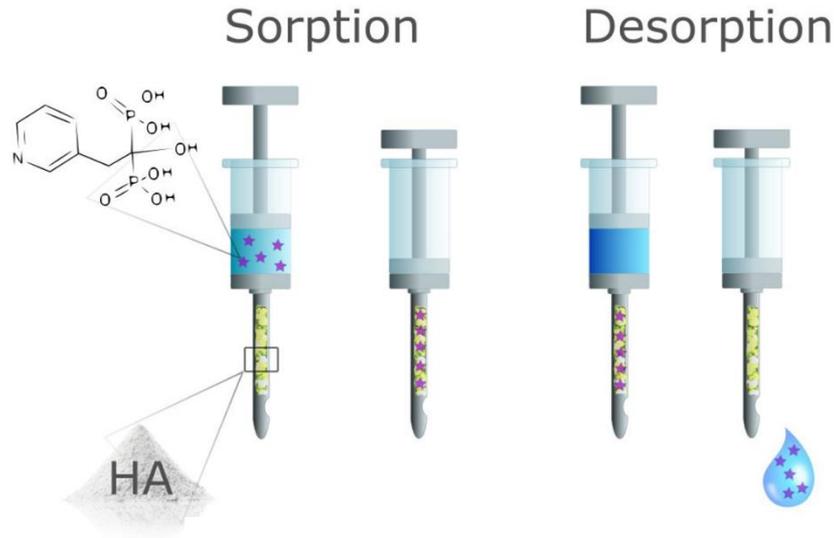
# ILC - Surface properties / Abraham



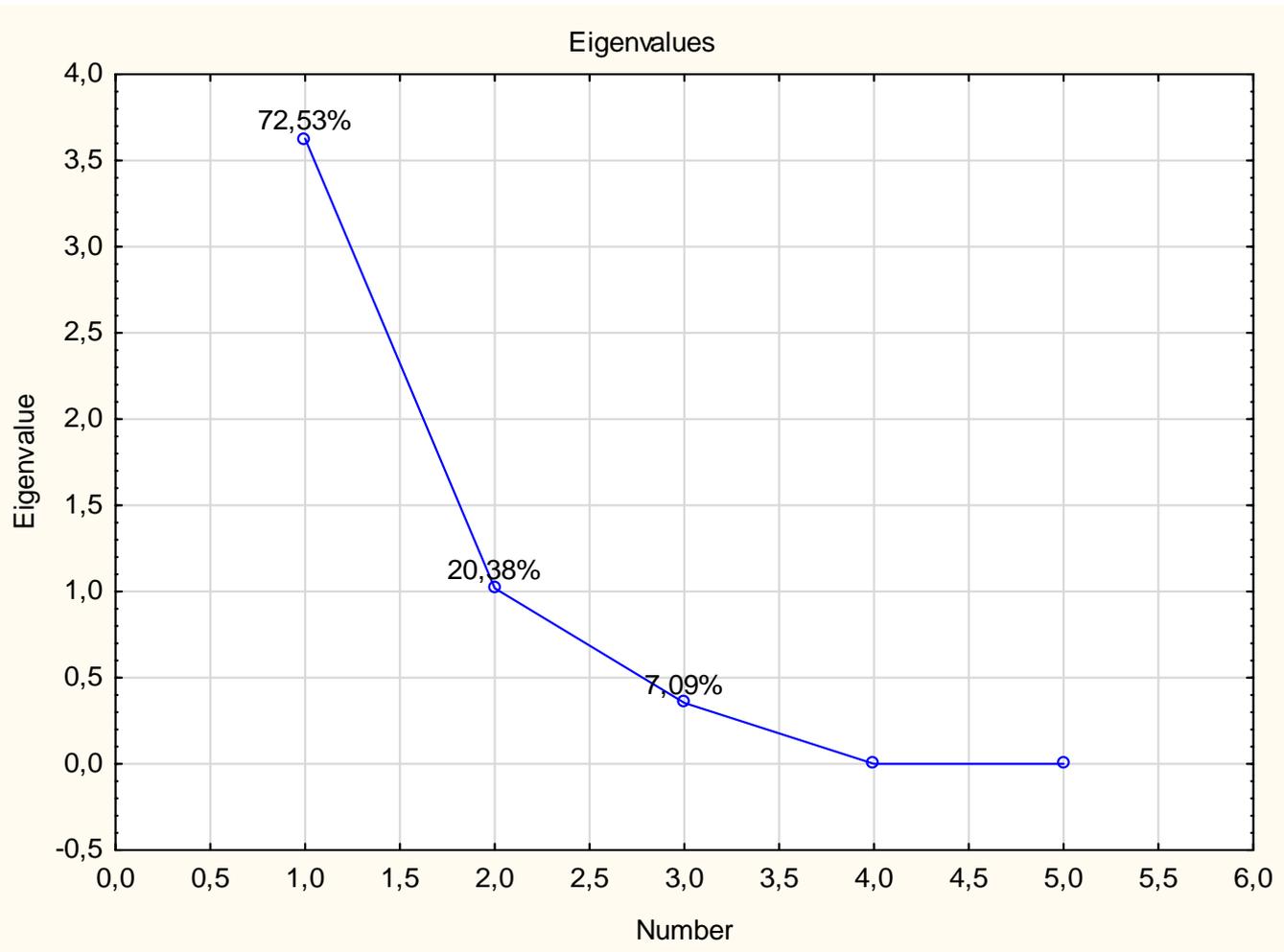
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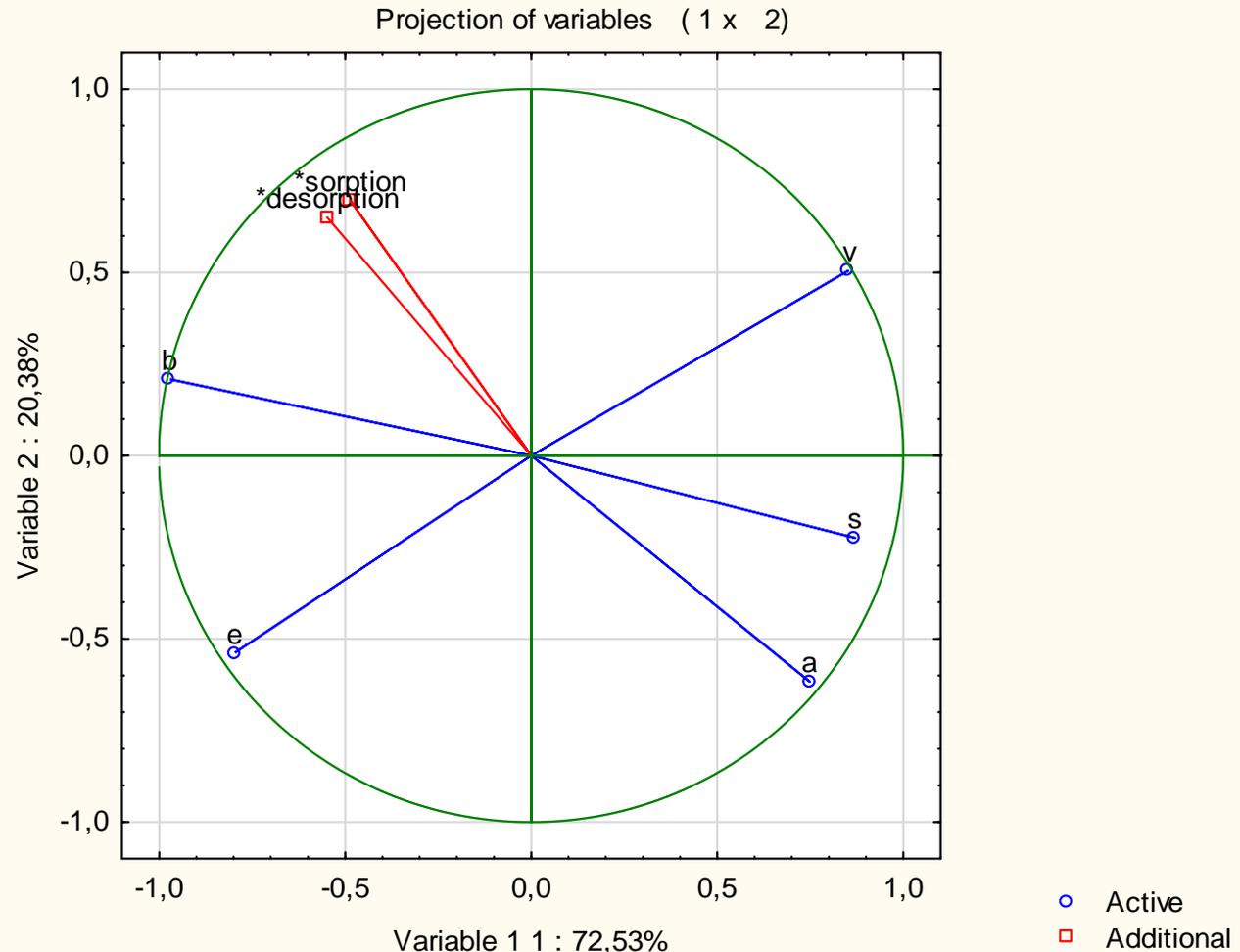
# Examination of sorption and desorption



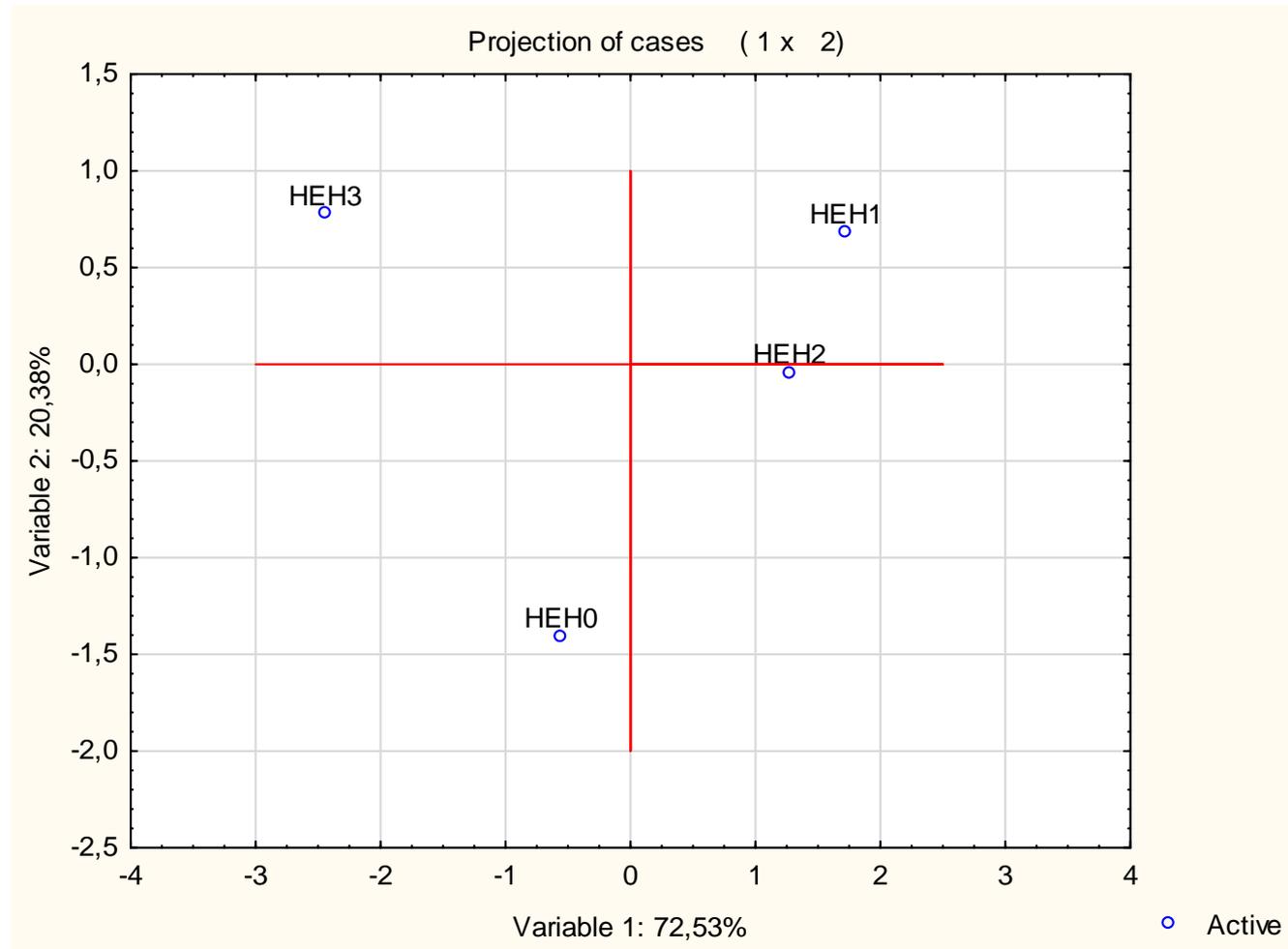
# Principal Component Analysis (PCA) / materials characterisation



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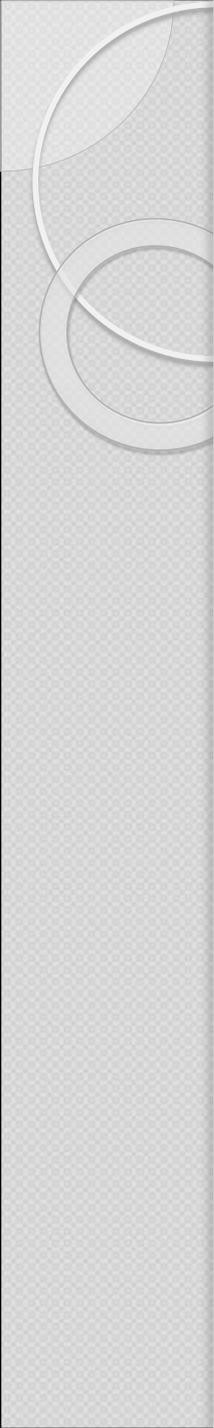


# Principal Component Analysis (PCA) / materials characterisation



# Conclusions

- Inverse liquid chromatography technique can be applied for characterization of the hydroxyapatite-polymer monolithic columns.
- LSER provide a relatively unambiguous understanding of the importance of the various interactions governing the thermodynamics of the system being studied.
- All materials shows ability to the dispersive interactions, through  $\pi/n$ -electrons pairs ( $e$  parameter) – the higher content of HA, the higher ability to such type of interactions.
- According to PCA data, the highest correlation of Risedronate sorption/desorption process onto HEH has been found for  $a$  parameter – the ability to accept a hydrogen bond could make the most contribution to the sorption/desorption proces, probably.
- HEH monolithic column would provide a useful tool to investigate newly synthesized BPs for better understanding process of their action.



**Thank you for your attention**