FAPESP
SÃO PAULO RESEARCH FOUNDATION

Optimization of conditions for obtaining hydrogels of PVA/SMTP and evaluation of the presence of crosslinks between chains

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Definition of biomaterials

The biomaterial can be defined as natural or synthetic biological compound used in contact with the intention to treat, augment or replace tissue, organs or body functions being formed mainly from metals, ceramic materials and polymer materials systems

Application:

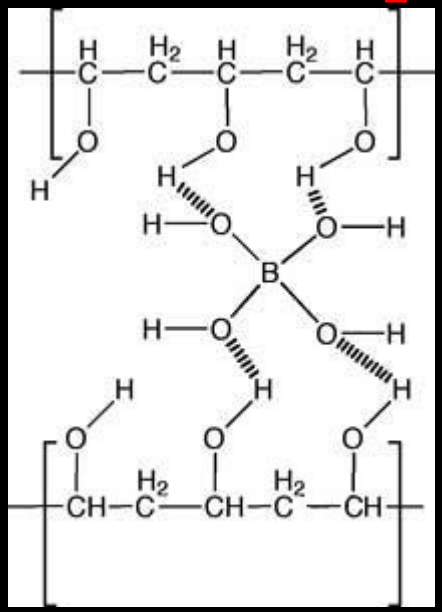
- Dermatology (prosthetic filling, release transdermal drug delivery system).
- Ophthalmology (vitreous replacements, contact lenses, intraocular drug release) among others.

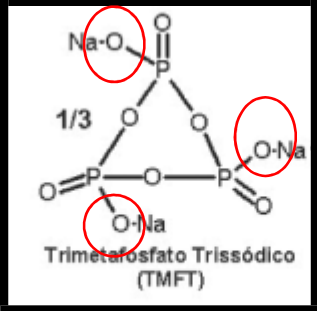
Okaya T., Suzuki A., Kikuchi K. Colloids and Surfaces A: Physiochemical and Engineering Aspects. V.153, p.123-125, 1999.
Swindle-Reilly K. E., Shah M., Hamilton P. D., Eskin T.A., Kaushal S., Ravi N. Investigative Ophthalmology & Visual Science, v.50, n.10, p.4840-4846, 2009.

Definition of hydrogels

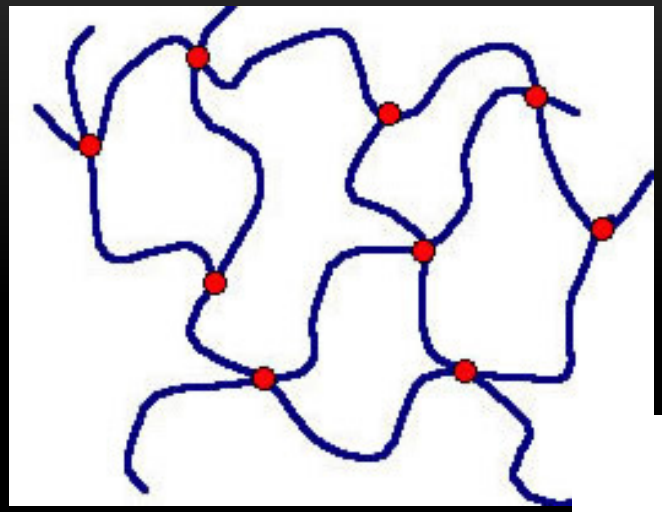
Crosslinked polymeric material which retains a significant fraction of water in its structure but without dissolving.
The crosslinking between chains can be obtained from:

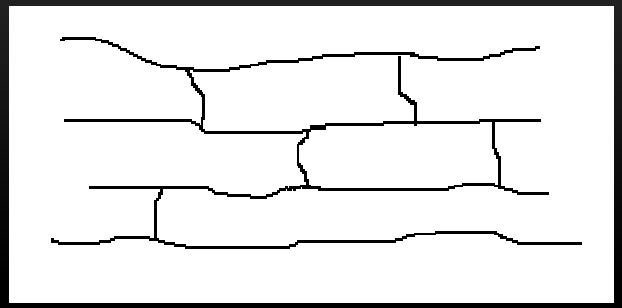
- ❑ **covalent interactions**
- ❑ **Physical interactions (eg, intermolecular interaction)**

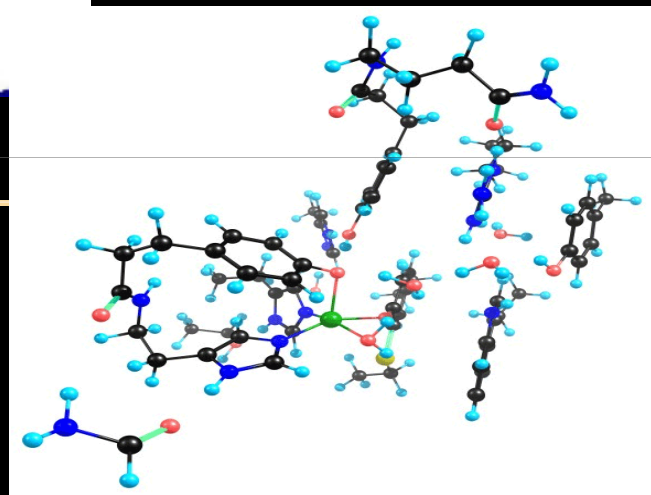


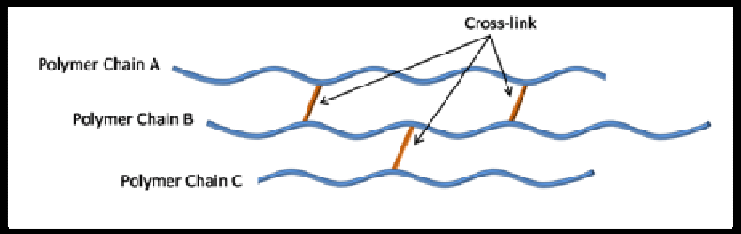


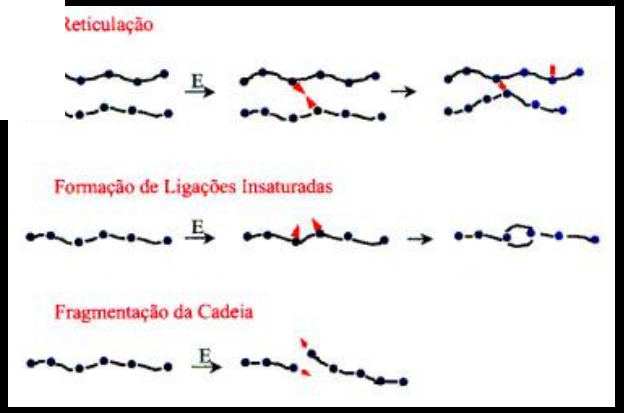
Crosslinked hydrogels











Choose the matrix

While obtaining possible hydrogels, it is possible to use various polymers alone or as blends as matrices. E.g.

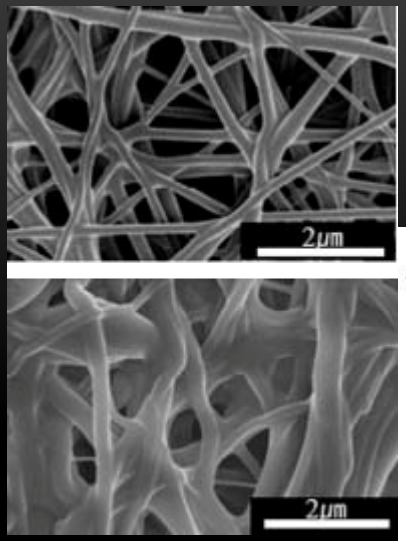
- ❑ polyvinyl alcohol
- ❑ polyacrylamide
- ❑ Chitosana
- ❑ methylcellulose
- ❑ starch
- ❑ Methyl Methacrylate
- ❑ polyvinylpyrrolidone
- ❑ polysaccharides
- ❑ hydroxyapatite

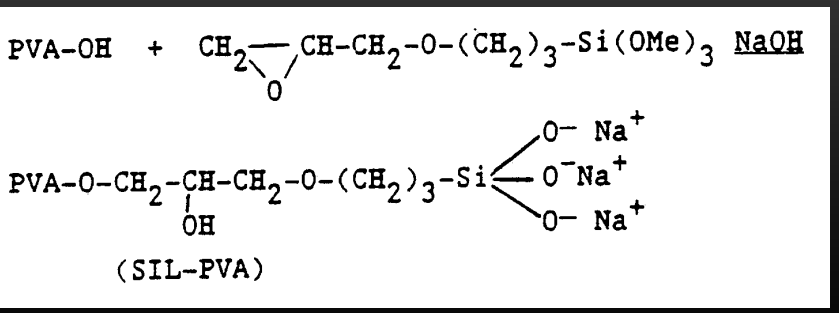
Chirila T.V., Hongb Y., Dalton P.D., Constable I.J., Refojo M.F. Progress in Polymer Science. V.23, p.475-508, 1998.
Okaya T., Suzuki A., Kikuchi K. Colloids and Surfaces A: Physiochemical and Engineering Aspects. V.153, p.123-125, 1999.
Swindle-Reilly K. E., Shah M., Hamilton P. D., Eskin T.A., Kaushal S., Ravi N. Investigative Ophthalmology & Visual Science, v.50, n.10, p.4840-4846, 2009.

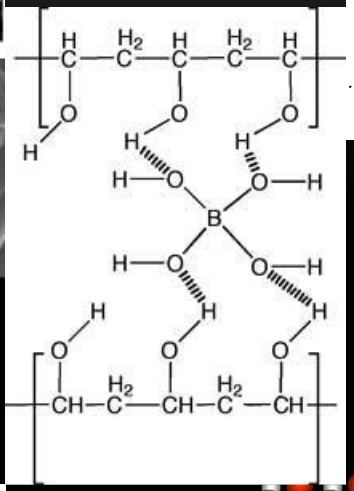
Selection of crosslinker agents

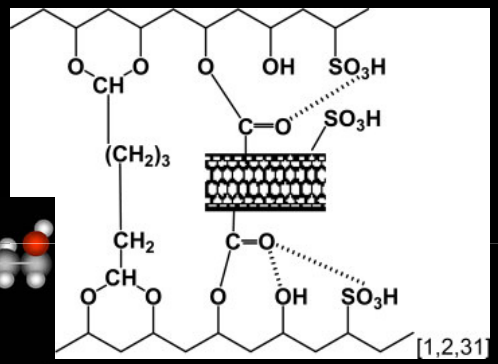
Regarding primers crosslinking, we can include:

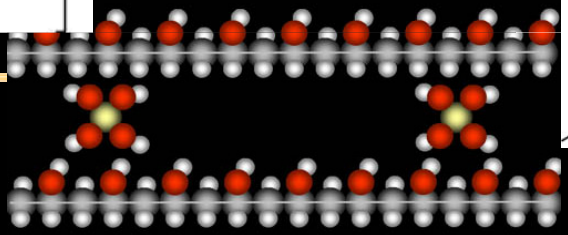
- ionizing radiation
- 1,5-hexadiene-3 ,4-diol
- Ammonium persulfate
- Ethylene diacrylate
- glutaraldehyde
- genipin
- Trisodium trimetaphosphate

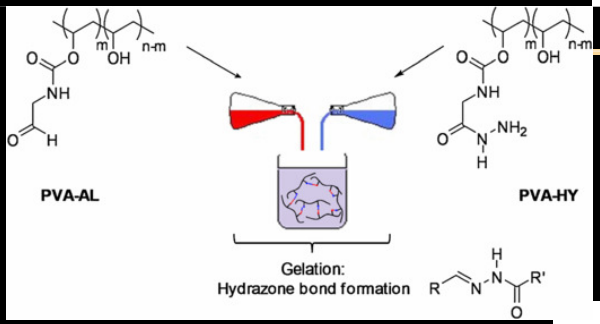

2μm
2μm

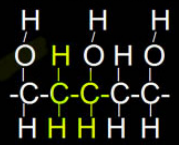

PVA-OH + CH2—CH-CH2-O-(CH2)3-Si(OMe)3 NaOH
O
PVA-O-CH2-CH-CH2-O-(CH2)3-Si
OH
O− Na+
O−Na+
O− Na+
(SIL-PVA)

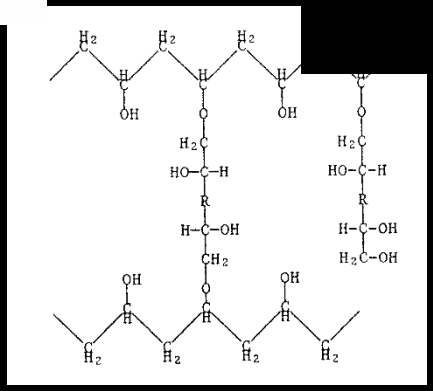


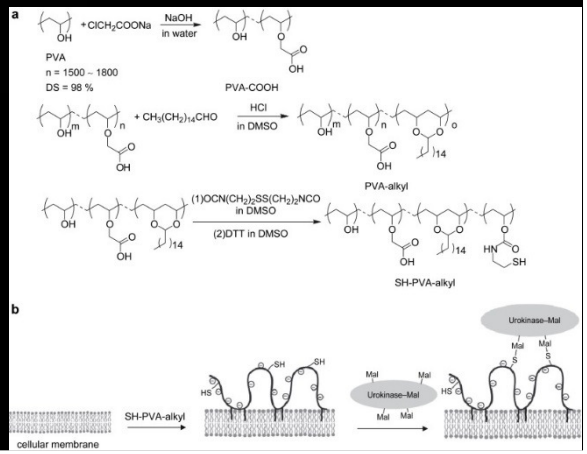

SO3H
SO3H
(CH2)3
CH2
SO3H
[1,2,31]




PVA-AL
PVA-HY
Gelation:
Hydrazone bond formation






PVA
n = 1500 ~ 1800
DS = 98 %
PVA-COOH
PVA-alkyl
SH-PVA-alkyl
SH-PVA-alkyl
cellular membrane
Urokinase-Mal

Physical and chemical characterizations

Characterizations, include:

- ❑ mechanical properties
- ❑ rheological Testing
- ❑ viscosity
- ❑ density
- ❑ infra red
- ❑ Scanning electron microscopy
- ❑ X-Ray Diffraction
- ❑ thermal analysis
- ❑ Refractive Index
- ❑ Swell Grade
- ❑ Fraction sol / gel

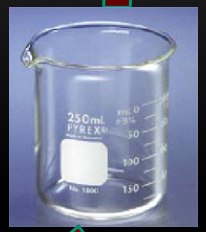
Biological characterizations

Biological characterizations:

- **cytotoxicity**
- **microbiological**
- **“*In vitro*" tests**
- **“*In vivo*“ tests**

PVA hydrogel with SMTP

100 mL water
5 g de PVA
0.625 g SMTP



agitation
T = 80ºC
T = 2 h

hydrogel

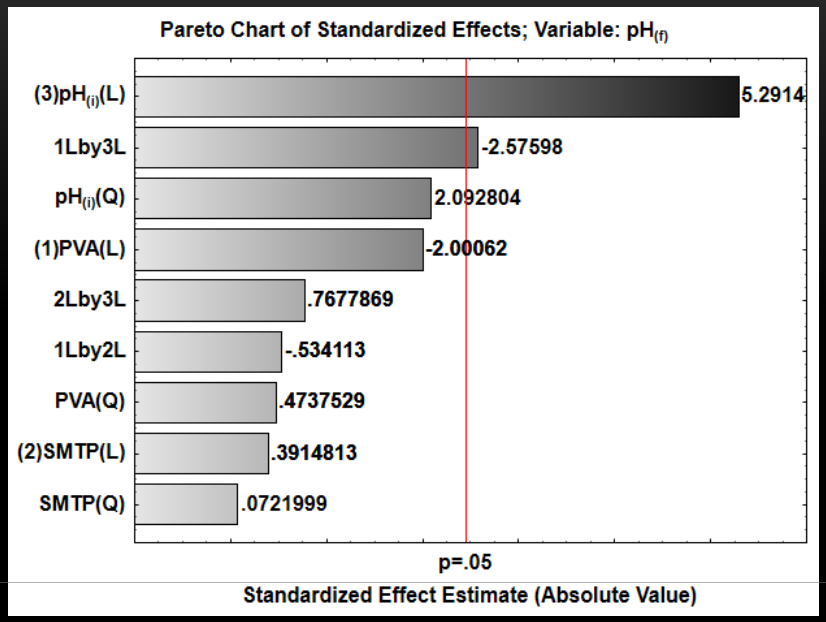
Refractive Index
Density
Viscosity

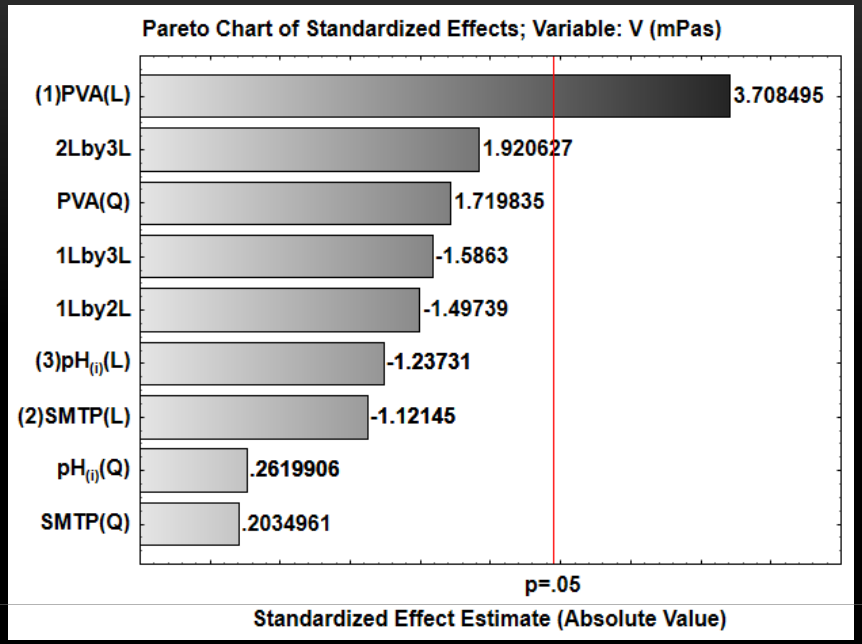
Property	Unit
Weight	4 g
Density	1.0053-1.0089 g/cm
Water content	98-99%
pH	7.0-7.4
Viscosity	4.0-4.2 mPa
Refractive Index	1.3345-1.3348

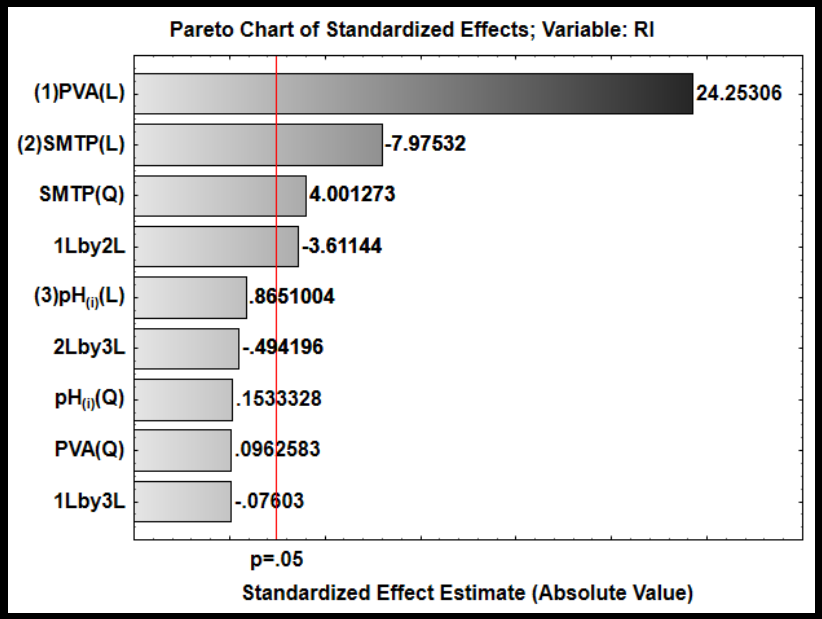
Experimental Design

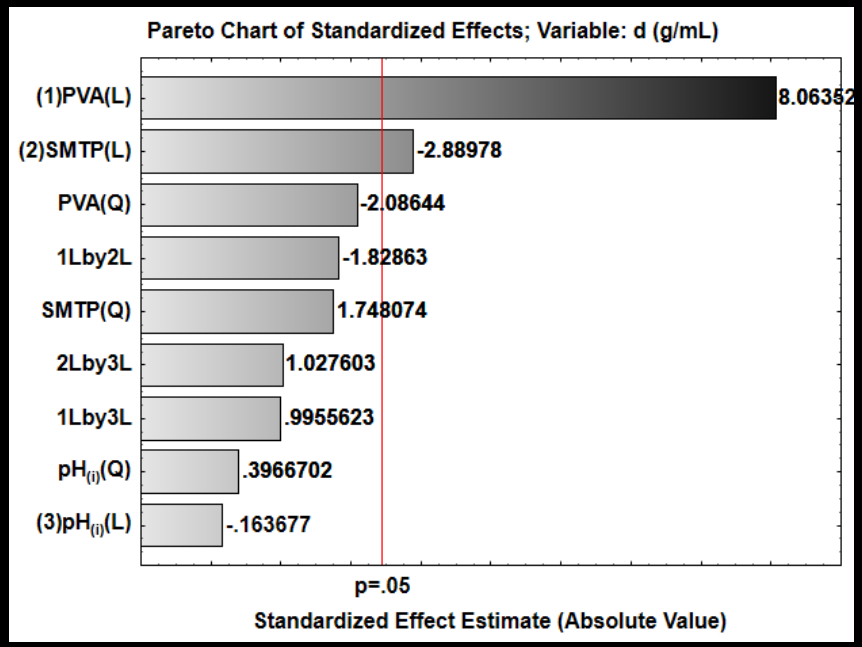
codedvariables			Non-codedvariables		
PVA	SMTP	pH	PVA	SMTP	pH
0	$+\sqrt{2}$	0	7.00	9.704	10.00
+1	+1	+1	10.00	8.000	12.00
+1	-1	-1	10.00	3.000	8.00
0	0	0	7.00	5.500	10.00
-1	+1	+1	4.00	8.000	12.00
0	$-\sqrt{2}$	0	7.00	1.296	10.00
$-\sqrt{2}$	0	0	1.95	5.500	10.00
0	0	$+\sqrt{2}$	7.00	5.500	13.36
-1	1	+1	4.00	3.000	12.00
$+\sqrt{2}$	0	0	12.05	5.500	10.00
0	0	$-\sqrt{2}$	7.00	5.500	6.64
0	0	0	7.00	5.500	10.00
+1	+1	-1	10.00	8.000	8.00
+1	-1	+1	10.00	3.000	12.00
-1	+1	-1	4.00	8.000	8.00
-1	-1	-1	4.00	3.000	8.00

Results and Discussion







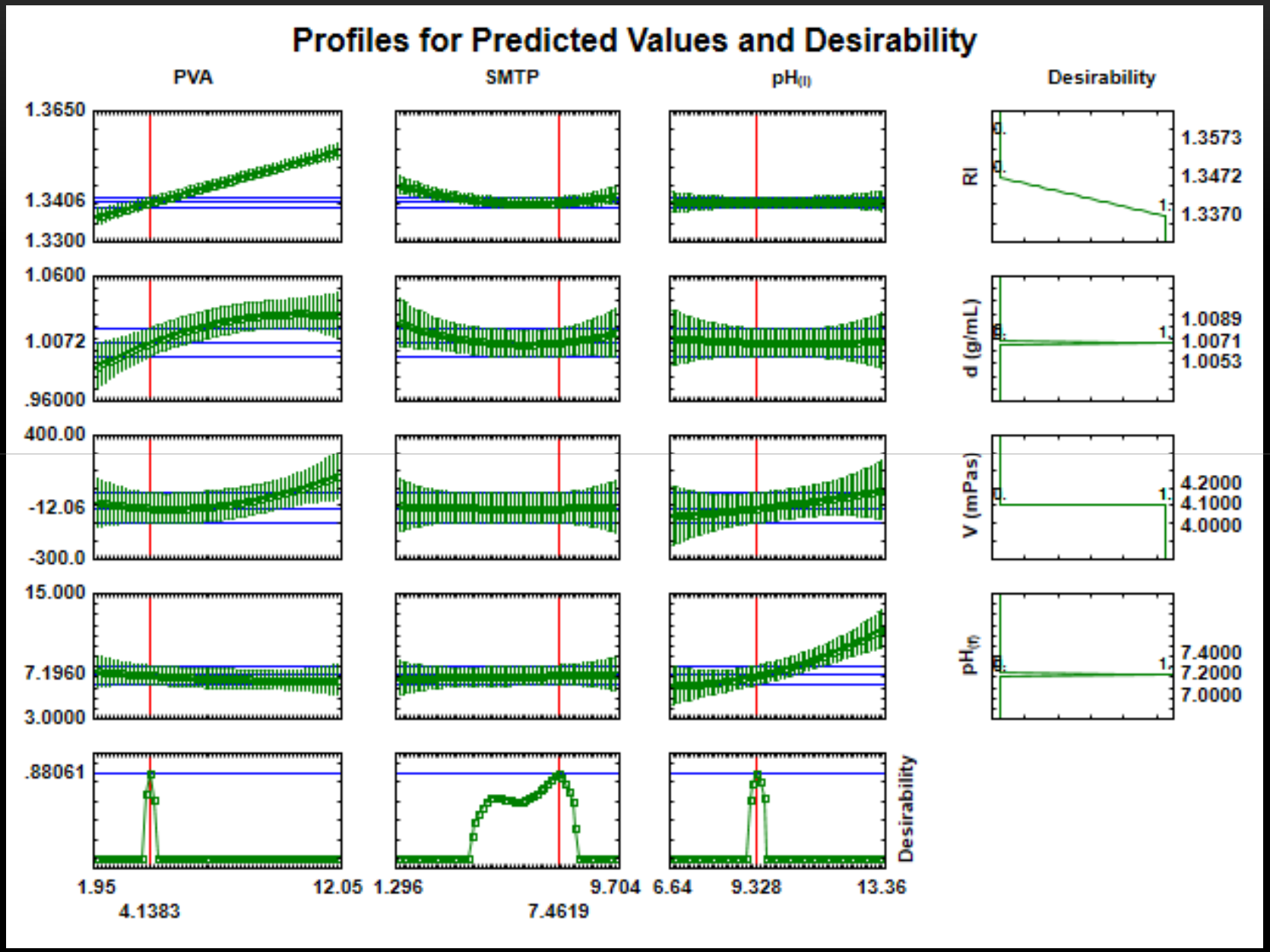


Results and Discussion

Parameters used during the analysis:

- **Final pH: Between 7.0 and 7.4 (optimum = 4.2)**
- **Index of Refraction: <1.337**
- **Dynamic viscosity (25 ° C): Between 4.0 and 4.2 (optimum = 4.1)**
- **Density (25 º C): Between 1.0053 and 1.0089 (ideal = 1.0071)**

Results and Discussion



Analysis of results

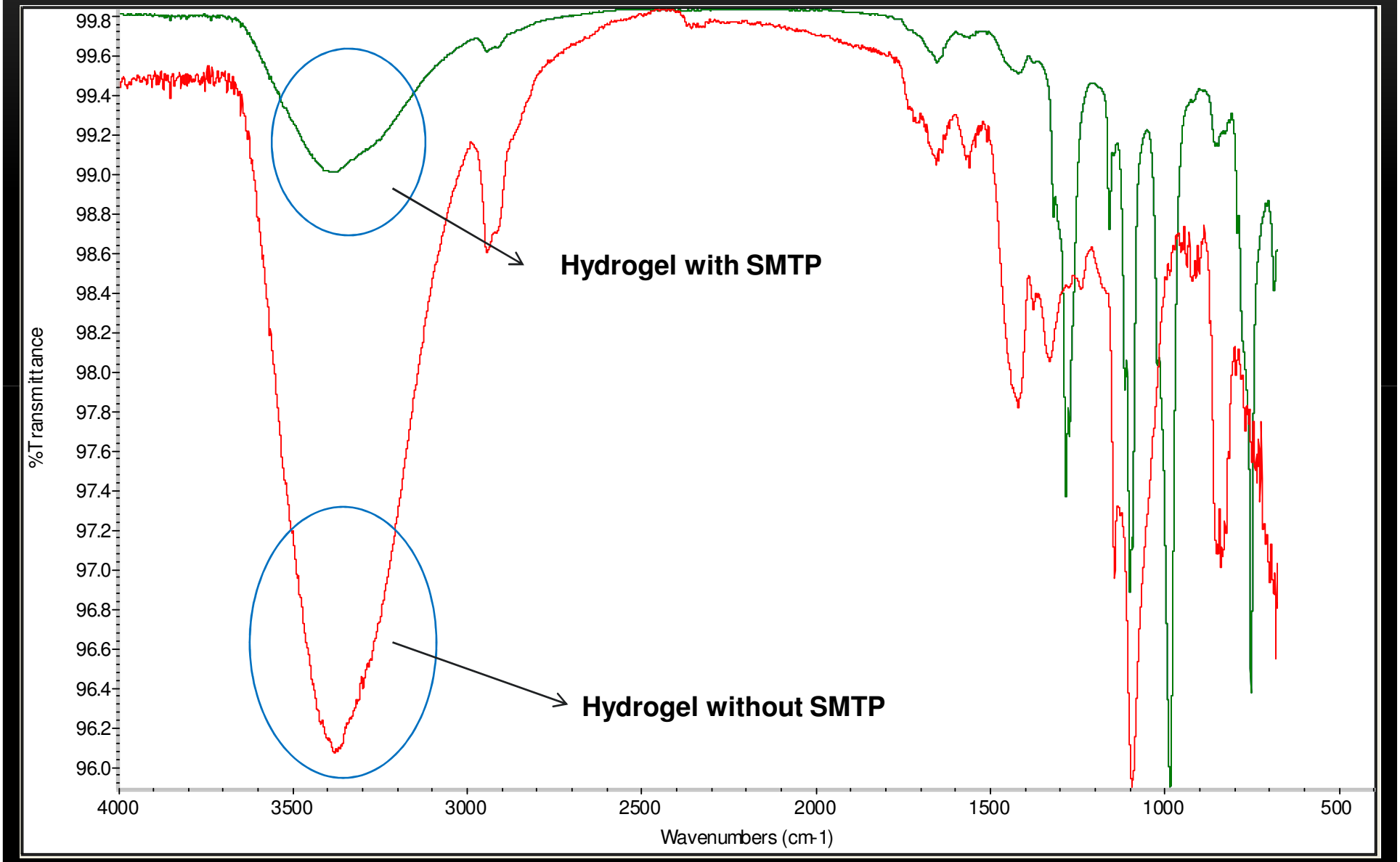
Optimized input variables:

- Initial pH: 9.328
- Mass of polyvinyl alcohol per 100 ml water: 4.1383 g
- Relationship SMTP / PVA: 1/7.4619

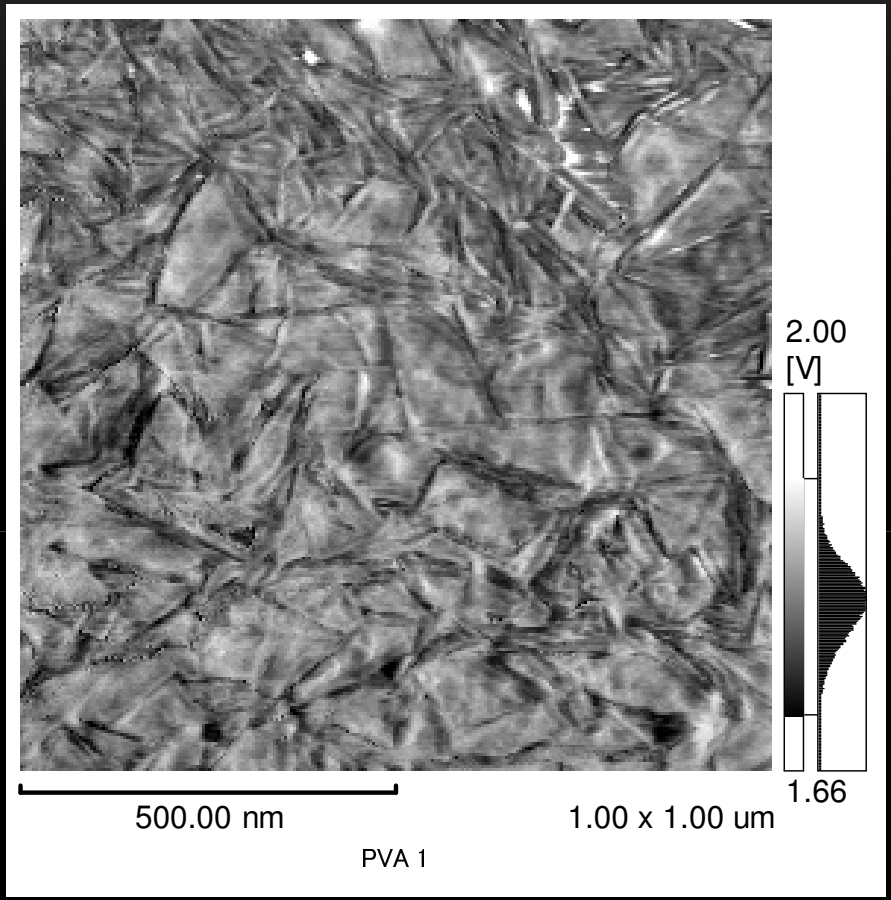
Optimized output variables

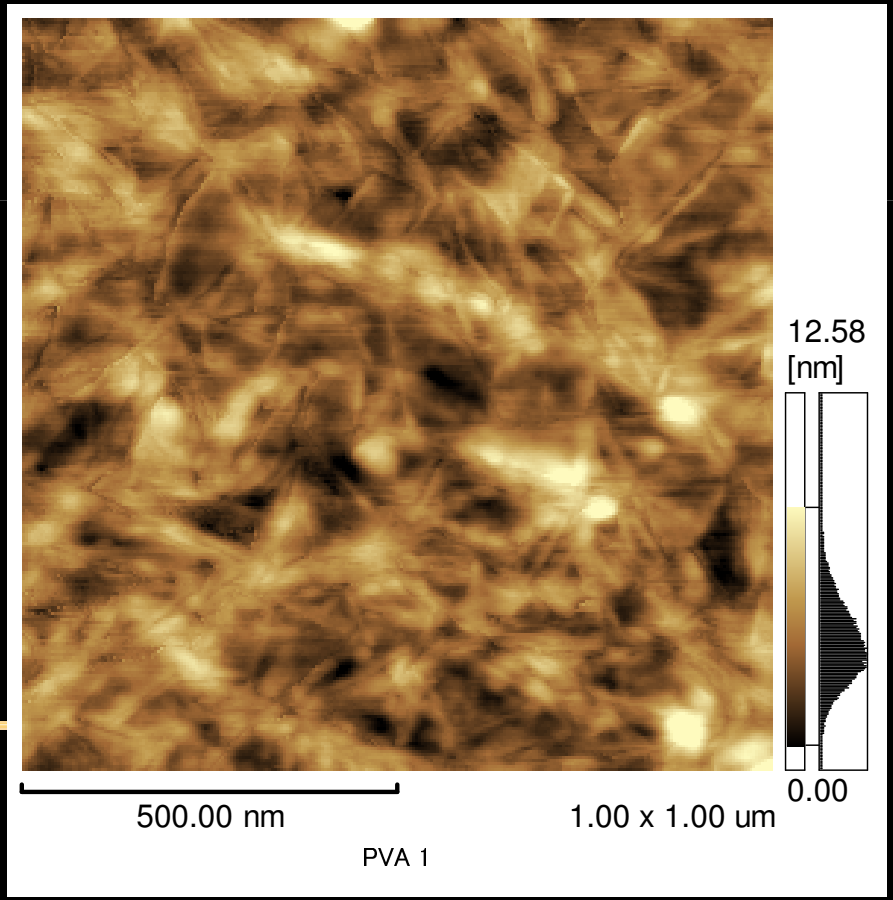
- Final pH: 7.20
- Refractive Index: 1.3407
- Dynamic viscosity (25 ° C): 4.617 mPa
- Density (25 º C): 1.0071 g / mL

Infrared spectra



Analysis by atomic force microscopy





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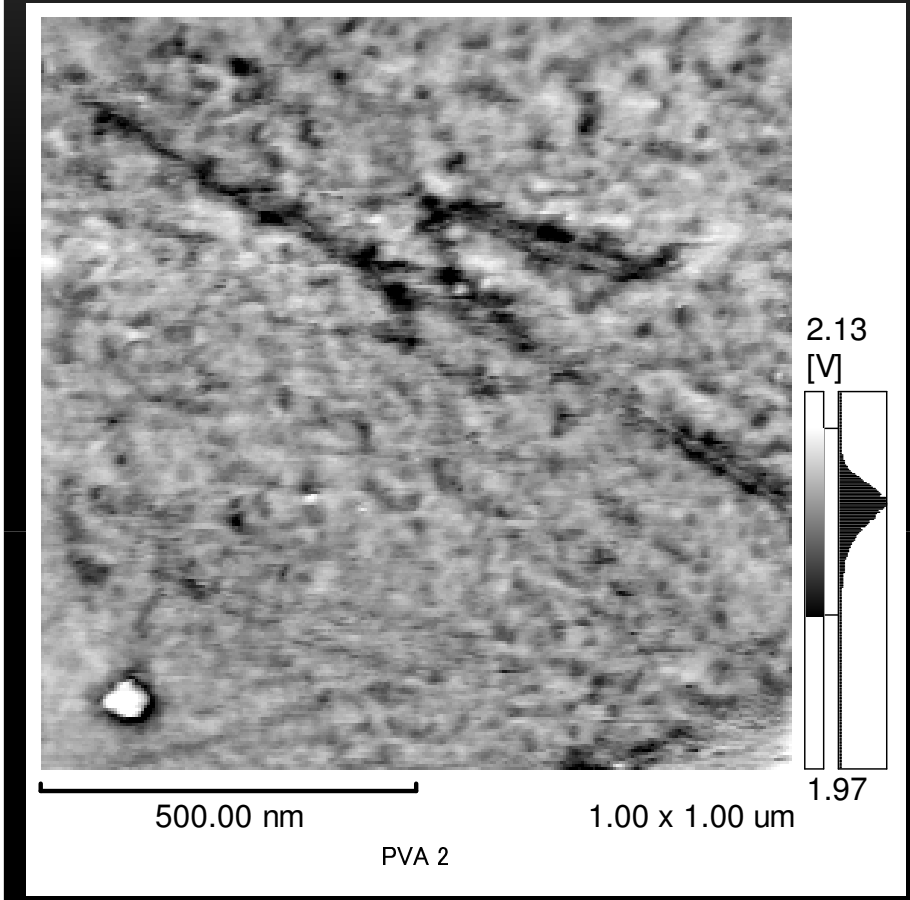
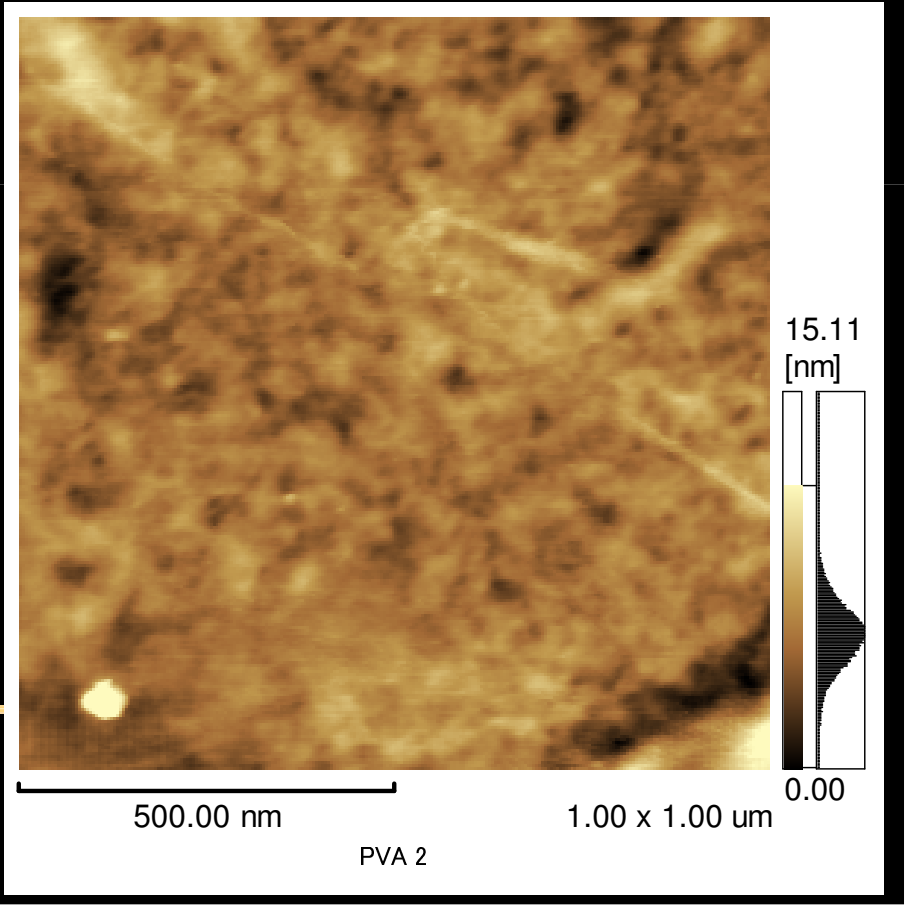
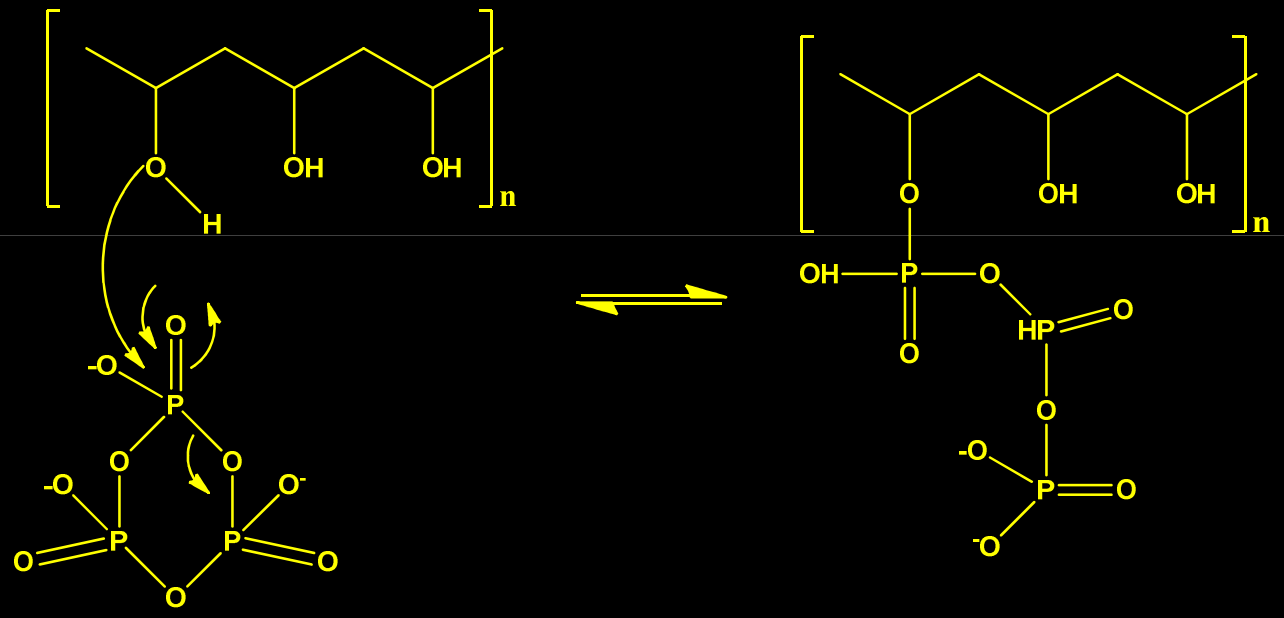




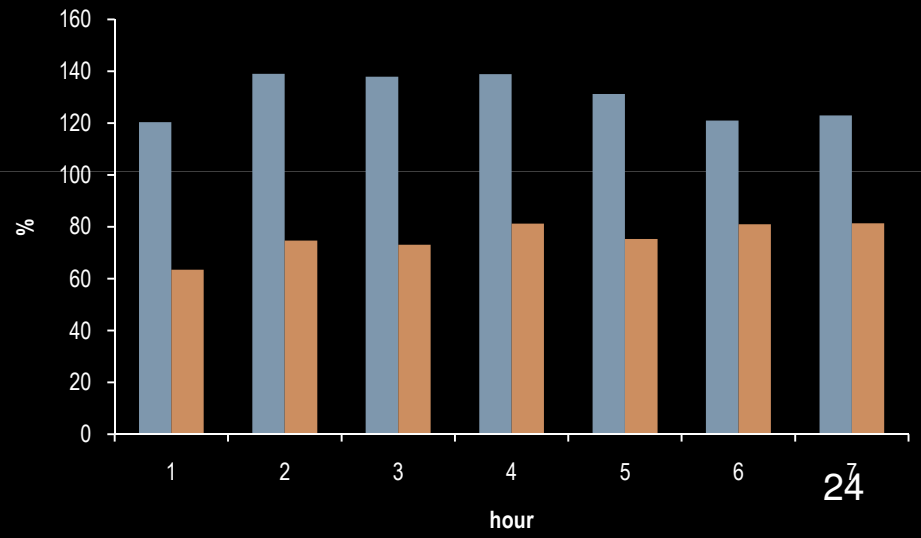
Analysis by atomic force microscopy

We observe a more compact material because of the presence of crosslinking between the PVA and the SMTP



Biomaterial Properties

Changes in ownership of swelling due to lower availability of hydrogen bonds and larger space between the chains



Degree of swelling of hydrogels with or without SMTP

Conclusion

- The biomaterial obtained had the necessary characteristics
- Crosslinking between PVA and SMTP was checked due to the observed changes in the material
- The SMTP was important to obtain the required specification

Team

- Andreia de Araújo Morandim Giannetti
- Octaviano Magalhães Junior
- Patrícia Alessandra Bersanetti
- Paulo Schor
- Regina Freitas Nogueira
- Wallace Chamon Alves de Siqueira

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