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.

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 (e.g., intermolecular interaction)
Crosslinked hydrogels
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

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
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:

- 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

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Weight</td>
<td>4 g</td>
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<tr>
<td>Density</td>
<td>1.0053-1.0089 g/cm</td>
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<tr>
<td>Water content</td>
<td>98-99%</td>
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<tr>
<td>pH</td>
<td>7.0-7.4</td>
</tr>
<tr>
<td>Viscosity</td>
<td>4.0-4.2 mPa</td>
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<tr>
<td>Refractive Index</td>
<td>1.3345-1.3348</td>
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### Experimental Design

<table>
<thead>
<tr>
<th>codedvariables</th>
<th>Non-codedvariables</th>
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<tbody>
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<td>SMTP</td>
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</tr>
</tbody>
</table>
Results and Discussion

Pareto Chart of Standardized Effects; Variable: pH_0

- (3)pH_0(L): 5.2914
- 1Lby3L: -2.57598
- pH_0(L): 2.092804
- (1)PVA(Q): -2.00062
- 2Lby3L: 0.7677869
- 1Lby2L: -0.534113
- PVA(Q): 0.4737529
- (2)SMTP(L): -0.3914813
- SMTP(Q): 0.0721999

p = 0.05

Standardized Effect Estimate (Absolute Value)

Pareto Chart of Standardized Effects; Variable: V (mPas)

- (1)PVA(L): 3.708495
- 2Lby3L: 1.920827
- PVA(Q): 1.719835
- 1Lby3L: -1.5863
- 1Lby2L: -1.49739
- (3)pH_0(L): -1.23731
- (2)SMTP(L): -1.12145
- pH_0(Q): 0.261906
- SMTP(Q): 0.2034961

p = 0.05

Standardized Effect Estimate (Absolute Value)

Pareto Chart of Standardized Effects; Variable: RI

- (1)PVA(L): 24.25306
- (2)SMTP(L): -7.97532
- SMTP(Q): 4.001273
- 1Lby2L: 3.61144
- (3)pH_0(L): -0.8615004
- 2Lby3L: -0.454196
- pH_0(Q): -0.153328
- PVA(Q): 0.092863
- 1Lby3L: -0.07803

p = 0.05

Standardized Effect Estimate (Absolute Value)

Pareto Chart of Standardized Effects; Variable: d (g/mL)

- (1)PVA(L): 8.06382
- SMTP(L): -2.28978
- SMTP(Q): 2.086844
- 1Lby2L: -1.82863
- SMTP(Q): 1.748074
- 2Lby3L: 1.027603
- 1Lby3L: 0.9966623
- pH_0(Q): 0.3966702
- (3)pH_0(L): -1.63877

p = 0.05

Standardized Effect Estimate (Absolute Value)
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 °C)**: Between 1.0053 and 1.0089 (ideal = 1.0071)
Results and Discussion

Profiles for Predicted Values and Desirability

- PVA
- SMTP
- pH
- Desirability

Values:
- RI: 1.3573, 1.3472, 1.3370
- d (g/mL): 1.0089, 1.0071, 1.0053
- V (mPa.s): 4.2000, 4.1000, 4.0000
- pH: 7.4000, 7.2000, 7.0000
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

Hydrogel with SMTP

Hydrogel without SMTP

Wavenumbers (cm$^{-1}$)

%Transmittance
Analysis by atomic force microscopy

PVA 1

500.00 nm
1.00 x 1.00 um

2.00
1.66

12.58
0.00

nm

nm
Analysis by atomic force microscopy
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

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