



UNIVERSITÀ DEGLI STUDI DI SALERNO

**Dipartimento di Ingegneria Industriale**

Corso di Laurea in Ingegneria Chimica

# **Caratterizzazione di idrogel chimici a base di idrossietilcellulosa**

Tesi in

**Principi di Ingegneria Chimica**

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**Anno Accademico 2018/2019**



*Ai miei genitori*

Questo testo è stato stampato in proprio, in Times New Roman

La data prevista per la discussione della tesi è il 27/09/2019

Fisciano, 13/09/2019

# Sommario

<b>Sommario .....</b>	<b>I</b>
<b>Indice delle figure .....</b>	<b>V</b>
<b>Indice delle tabelle .....</b>	<b>VII</b>
<b>Abstract .....</b>	<b>IX</b>
<b>Introduzione.....</b>	<b>1</b>
1.1 Generalità degli idrogel _____	2
1.2 Campi di applicazione _____	5
1.2.1 Ingegneria biomedica	5
1.2.2 Sistemi per il rilascio controllato	7
1.2.3 Ingegneria tissutale	9
1.3 Tecniche di gelificazione _____	10
1.3.1 Crosslinking fisico	11
1.3.2 Crosslinking chimico	13
1.4 Fisica dei gel _____	14
1.4.1 Teoria di Flory-Huggins	15
1.4.2 Rubber Elasticity Theory	15
1.4.3 Termodinamica dello swelling	17
1.5 Caratterizzazione degli idrogel _____	20
1.5.1 Proprietà di swelling	20
1.5.2 Proprietà meccaniche	21
1.6 Stato dell'arte _____	25

---

1.6.1	Trattamento del low back pain	25
1.6.2	Caratterizzazione meccanica	29
1.7	Obiettivi	33
<b>Materiali, apparecchiature e metodi.....</b>		<b>35</b>
2.1	Materiali	36
2.1.1	Idrossietilcellulosa (HEC)	36
2.1.2	Divinil solfone (DVS)	36
2.2	Apparecchiature	37
2.2.1	Texture Analyzer	37
2.3	Metodi	38
2.3.1	Preparazione della soluzione di HEC al 3%	38
2.3.2	Preparazione degli idrogel	38
2.3.3	Reazione di crosslinking tra HEC e DVS	40
2.3.4	Valutazione del grado di swelling con analisi gravimetriche	41
2.3.5	Prova di stress-rilassamento	42
<b>Risultati e discussione.....</b>		<b>45</b>
3.1	Prove gravimetriche	46
3.1.1	Rapporto HEC: DVS 3:1	47
3.1.2	Rapporto HEC: DVS 2:1	48
3.1.3	Rapporto HEC: DVS 1:1	49
3.2	Confronto gravimetriche	50
3.3	Test di stress rilassamento	52
3.3.1	Rapporto HEC:DVS 3:1	53
3.3.2	Rapporto HEC: DVS 2:1	55
3.3.3	Rapporto HEC: DVS 1:1	57
3.4	Confronto test di stress rilassamento	59
3.4.1	Effetto del reticolante	59
3.4.2	Perdita dell'acqua durante la prova al texture	60
<b>Conclusioni .....</b>		<b>61</b>

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Sommario e indici. Pag. III

---

4.1 Conclusioni 62

**Bibliografia.....65**

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## Indice delle figure

Figura 1 Mesh size caratteristica di un sistema di idrogel [2].	2
Figura 2 A sinistra lo stato sol, costituito da più catene polimeriche e a destra lo stato gel costituito da un'unica macromolecola [14].	11
Figura 3 A sinistra la soluzione di carragenina che dopo raffreddamento porta alla formazione di eliche, mentre in presenza di sali avremmo una configurazione più stabile a doppia elica [15].	12
Figura 4 Rappresentazione schematica di due modalità di deformazione in un gel [20].	14
Figura 5 Swelling di un polimero idrofilo in acqua. In (a) vediamo una tipica catena tra due crosslinks nel suo stato imperturbato. In (b) si rilassa lentamente mentre l'acqua viene incorporata fino all'equilibrio termodinamico [24].	19
Figura 6 Un esempio di compressione non confinata, a sinistra, e confinata, a destra [26].	22
Figura 7 Esempio di test stress-rilassamento [27].	23
Figura 8 Calcolo del modulo elastico attraverso la pendenza della zona lineare [28].	24
Figura 9 Struttura del disco intervertebrale [29].	26
Figura 10 Prove di stress-rilassamento del nucleus pulposus umano comparato con quelle degli idrogel testati [32].	28
Figura 11 Comportamento allo stress-relaxation test per compressione non confinata con una deformazione del 19% per i 3 tipi di rapporti HEC/DVS (2:1, 4:1, 10:1) [35].	30
Figura 12 Curve di rilassamento dello stress (a sinistra) e stress normalizzato con il valore massimo $\sigma_0$ (a destra) in caso di deformazione del 12% e un rapporto HEC / DVS pari a 2: 1 per diversi diametri di gel (5, 12, 20 mm) [35].	31
Figura 13 Valutazione del loss e storage moduli come funzioni della frequenza per una deformazione fissa 5% e tre rapporti HEC/DVS [35].	32
Figura 14 Unità ripetitiva della cellulosa e dell'idrossietilcellulosa.	36
Figura 15 Struttura del DVS.	37

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Figura 16 Texture analyzer TA.XT Plus, Stable Micro Systems Ltd. ....	38
Figura 17 Stampi utilizzati per la gelificazione appoggiati su un supporto. ....	40
Figura 18 Schema proposto per la reazione di reticolazione con DVS e rappresentazione schematica della reticolazione della rete polimerica [36]. ....	41
Figura 19 Esempio di grafico stress contro tempo in cui sono riportate le tre fasi del test e il punto in cui si misura la <i>trigger force</i> . ....	43
Figura 20 Analisi gravimetriche di idrogel con rapporto HEC/DVS 3:1. ....	47
Figura 21 Analisi gravimetriche di idrogel con rapporto HEC/DVS 2:1. ....	48
Figura 22 Analisi gravimetriche di idrogel con rapporto HEC/DVS 1:1. ....	49
Figura 23 Andamento delle frazioni massiche di polimero per ogni rapporto HEC/DVS. ....	51
Figura 24 Prova di stress-rilassamento per il rapporto 3:1. ....	53
Figura 25 Modulo di Young per rapporto 3:1. ....	54
Figura 26 Prova di stress-rilassamento per il rapporto 2:1. ....	55
Figura 27 Modulo di Young per rapporto 2:1. ....	56
Figura 28 Prova di stress-rilassamento per il rapporto 1:1. ....	57
Figura 29 Modulo di Young per rapporto 1:1. ....	58

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## Indice delle tabelle

Tabella 1 Alcune classificazioni per gli idrogel [4].....	4
Tabella 2 Valori del modulo elastico del nucleus pulposus ottenuti da diverse tecniche sperimentali [33]. .....	29
Tabella 3 Dimensione degli stampi utilizzata nei test. ....	29
Tabella 4 Quantità di divinilsolfone da aggiungere dopo aver fissato il volume della soluzione di HEC a 8,5 mL.....	39

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# Abstract

Hydrogels are three-dimensional hydrophilic polymeric networks, capable to absorb large quantities of water or biological fluids. The role of hydrogels is becoming increasingly important for many applications: among these those concerning the biomedical field and especially tissue engineering stand out. For this reason, studying the mechanical behavior of hydrogels has become of fundamental importance. This work aims to increase the knowledge about hydrogel's characteristics useful for the low back pain treatment, specifically for the nucleus pulposus replacement (central element of the intervertebral disc). To this purpose, hydrogels based on hydroxyethylcellulose (HEC), a non-ionic hydrophilic polymer derived from cellulose, covalently cross-linked with divinyl sulfone (DVS), have been produced. Gels were produced at different values of the ratio  $R$  between polymer (HEC) and crosslinking agent (DVS):  $R=3:1$ ,  $R=2:1$  e  $R=1:1$ . The mechanical and solvent transport properties were analyzed by stress-relaxation tests and gravimetric analyzes. The gels were extracted from the molds and left to equilibrate in pure water, they have shown a loss of weight over time and decreasing of swelling as the degree of cross-linking increases. These results have been explained with the Flory-Rehner theory suggesting that the elastic contribution in freshly cross-linked gels is always greater than the mixing one, leading to the contraction of the samples with consequent expulsion of water until a new equilibrium condition is reached. During the stress-relaxation test employed, a certain deformation is applied to the test sample and maintained for a certain time (3600 seconds), while the evolution of stress is monitored. Deformation values of 5, 10 and 15% were applied to the gels. Before and after each test, the gels were weighted to estimate the water lost during the stress-relaxation test. The analysis of Young's modules, obtained from the slope of the stress-deformation curve, confirm that,

by increasing the cross-linker ratio, the value of the elastic modulus of the gels also increases. This also affects the maximum stress values recorded, which increase as the cross-linking ratio increases. Increasing the deformation, the Young modulus increase, showing therefore a non-linear mechanics response  $E(\epsilon)$  characteristic of the large deformation. Once the HEC:DVS ratio has been fixed, the analyzes also show a level of relaxation that is not very marked for the 3:1 and 2:1 ratios, but higher in the case of the 1:1 ratio. A comparison of the analyzed gels with the mechanical characteristics of the nucleus pulposus was performed. The comparison showed that the 1:1 ratio gels are the best to simulate the characteristics of the nucleus pulposus and are possible candidates to replace it in biomedical applications.

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