Films for Food Packaging Based on Xylan From Agricultural Waste Residues

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Structure of the Presentation

- Introduction
- Lignocellulosic biomass
- The case for South Africa
- Hemicellulose
- Experimental
- Results and Discussion
- Conclusions

Introduction

- For Europe food packaging comprises of 66% of the post-consumer plastic waste
- Most of this plastic is produced from petroleum and is non-biodegradable
- An alternative is to produce these packaging materials from polysaccharides
- Hemicellulose consists of between 25-35% of lignocellulosic biomass
- There are an estimated 5 billion tons of agricultural waste residues produced every year

Lignocellulosic biomass

- Plant material derived from softwoods, hardwoods and grasses
- Comprised of three polymers
- Cellulose
- Hemicellulose
- Lignin

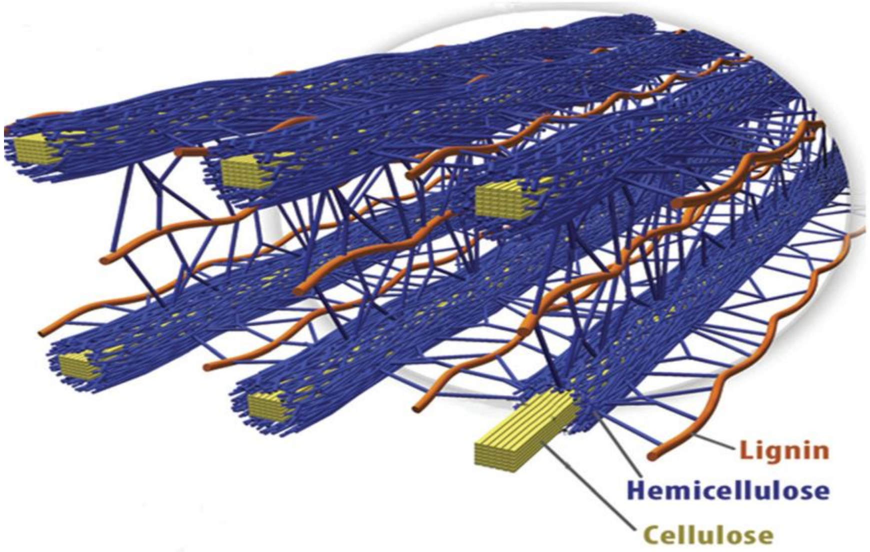

Figure 1: Structure of lignocellulose

The Case for South Africa

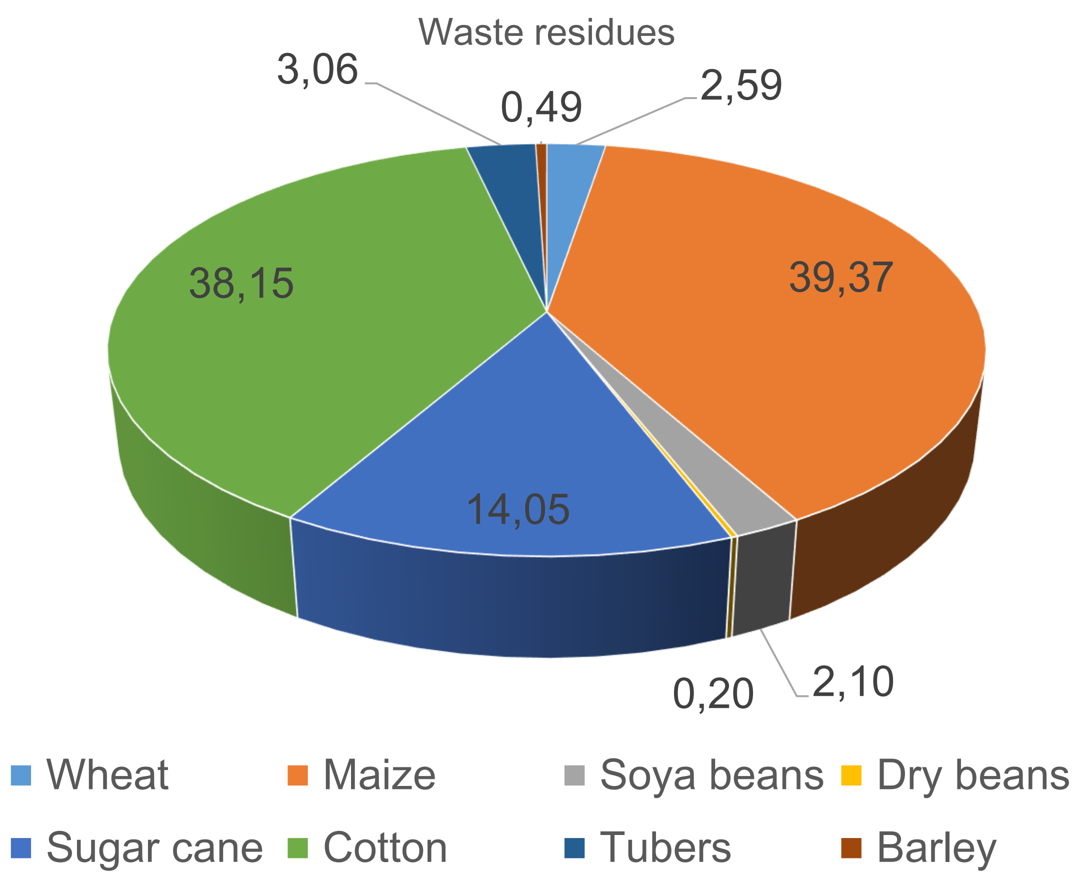

Figure 2: Types of agricultural waste residue in South Africa

Hemicellulose

- Family of heteropolymers
- Made up of pentoses and hexoses
- The solubility of the hemicellulose is influenced by the type of sugars in the polymer chain
- There are three main forms of hemicellulose
- Structure of hemicellulose varies with the plant species

Why Xylan

- Found in corn stalks and sugarcane bagasse
- Forms a transparent film
- Low oxygen permeability
- Biodegradable
- Edible

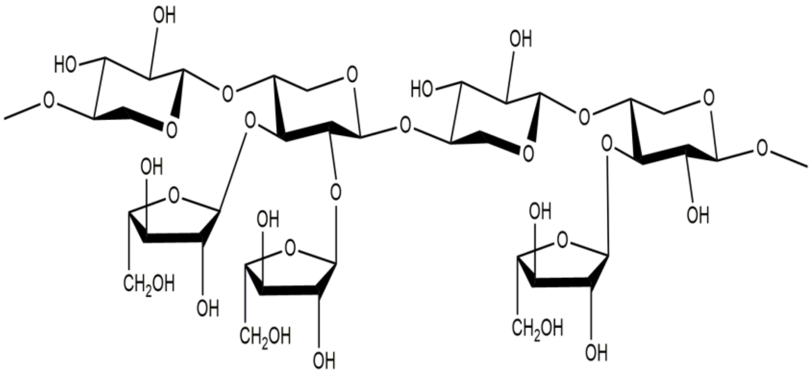

Figure 3: Structure of arabinoxylan

The Need for Alginate

- The mechanical properties of hemicellulose can vary
- Xylan is a poor moisture barrier
- In some cases xylan does not form films easily
- Alginate is widely available
- Biodegradable
- Edible

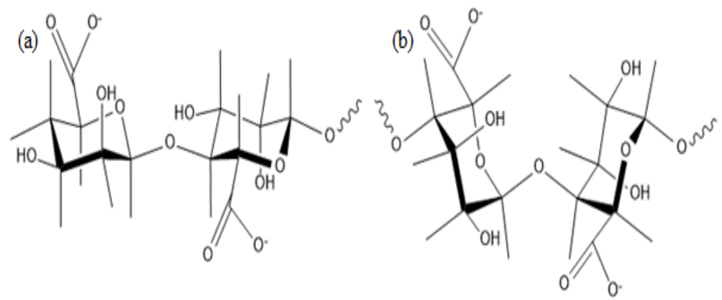

Figure 4: Structure of alginate

Experimental

Polymers are dissolved in water and the solution is the mixed

The solution is then sonicated

The dope is then decanted to moulds and dried overnight in a fan oven

Scheme 1: Procedure for film production

Table 1: Ratio of polymers

Sample	Alginate (%)	Xylan (%)	Glycerol (%)
1-2-8	31	61	8
1-1-8	46	46	8
2-1-8	61	31	8
1-2-10	30	60	10
1-1-10	45	45	10
2-1-10	60	30	10
1-2-12	29	59	12
1-1-12	44	44	12
2-1-12	59	29	12

Results and Discussion

- Colour testing
- Light transmittance
- Mechanical properties
- Thermogravimetric analysis
- Water vapour permeability
- Water Sorption

Sample of the films

Figure 5: Picture of alginate and xylan blend film

Colour testing

Table 2: Colour values of alginate and xylan blend films

Sample	L^*	a^*	b^*
Sheet of paper	93,81	-0,18	-4,47
1-2-8	90,67	-0,70	2,61
1-1-8	88,42	-0,55	5,27
2-1-8	87,66	-0,34	8,11
1-2-10	89,05	-0,67	3,66
1-1-10	88,75	-0,64	3,54
2-1-10	88,17	-0,53	6,10
1-2-12	89,49	-0,54	2,75
1-1-12	89,51	-0,52	4,25
2-1-12	88,76	-0,47	6,60

Light transmittance

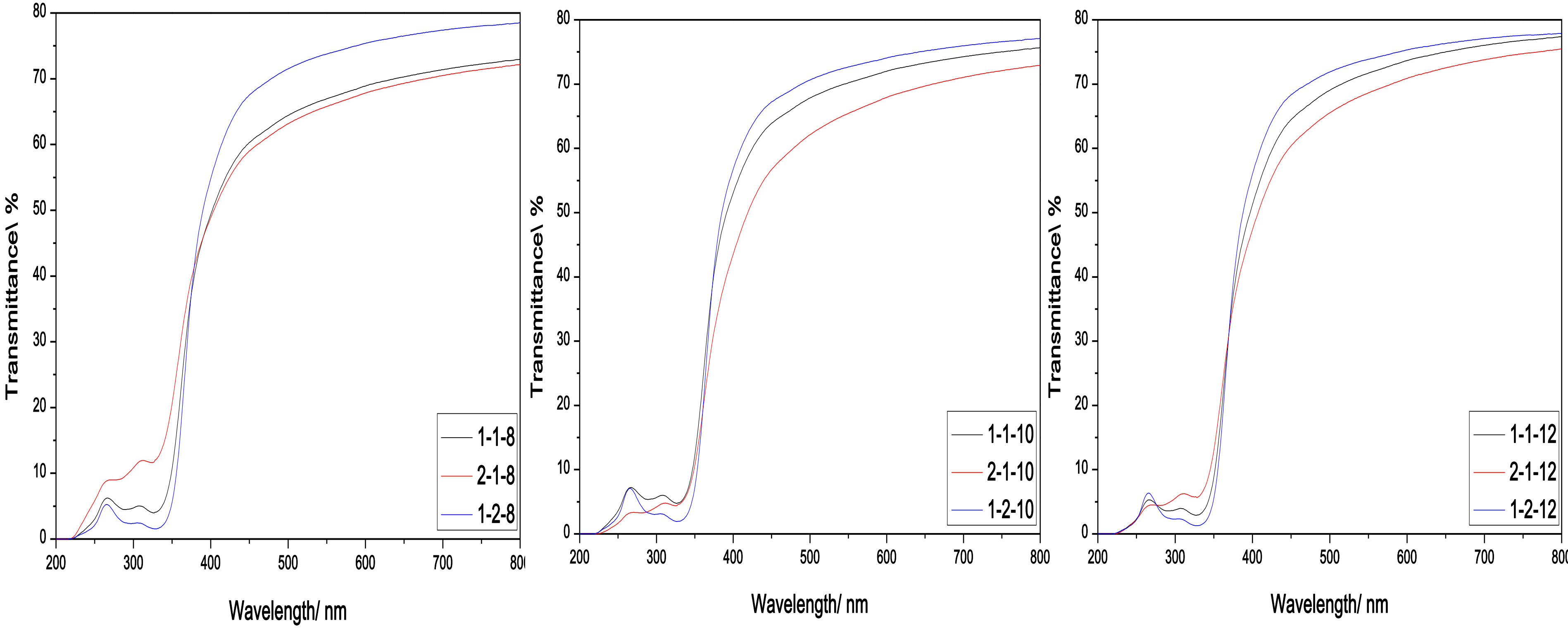

Figure 7: Transmittance spectra of (a) films containing 8% glycerol, (b) films containing 10% glycerol and (c) films containing 12% glycerol.

Mechanical properties

Table 3: Mechanical properties of alginate and xylan blend films

Name of sample	Elongation at break/ %	Stress at break/ MPa	Maximum load/ N	Young's modulus/ MPa
1-2-8 Al-Xyl-Gly	72.45 ± 9.21	2.99 ± 0.54	3.41 ± 0.61	6.44 ± 0.82
1-1-8 Al-Xyl-Gly	27.56 ± 6.87	17.52 ± 2.47	23.75 ± 3.94	83.97 ± 17.31
2-1-8 Al-Xyl-Gly	11.11 ± 2.29	10.46 ± 1.72	16.74 ± 2.75	162.2 ± 17.76
1-2-10 Al-Xyl-Gly	123.2 ± 17.68	3.28 ± 0.64	4.60 ± 0.90	4.48 ± 1.07
1-1-10 Al-Xyl-Gly	51.29 ± 5.89	8.87 ± 2.05	11.34 ± 2.46	31.91 ± 7.04
2-1-10 Al-Xyl-Gly	30.38 ± 4.80	13.07 ± 2.69	19.61 ± 4.04	75.96 ± 17.34
1-2-12 Al-Xyl-Gly	155.9 ± 27.19	1.65 ± 0.39	2.27 ± 0.54	1.28 ± 0.25
1-1-12 Al-Xyl-Gly	77.92 ± 6.52	4.94 ± 0.94	6.42 ± 1.22	12.10 ± 2.87
2-1-12 Al-Xyl-Gly	50.91 ± 8.94	11.77 ± 1.86	15.31 ± 2.42	43.85 ± 9.76
Polypropylene	535	23,1		

Thermogravimetric analysis

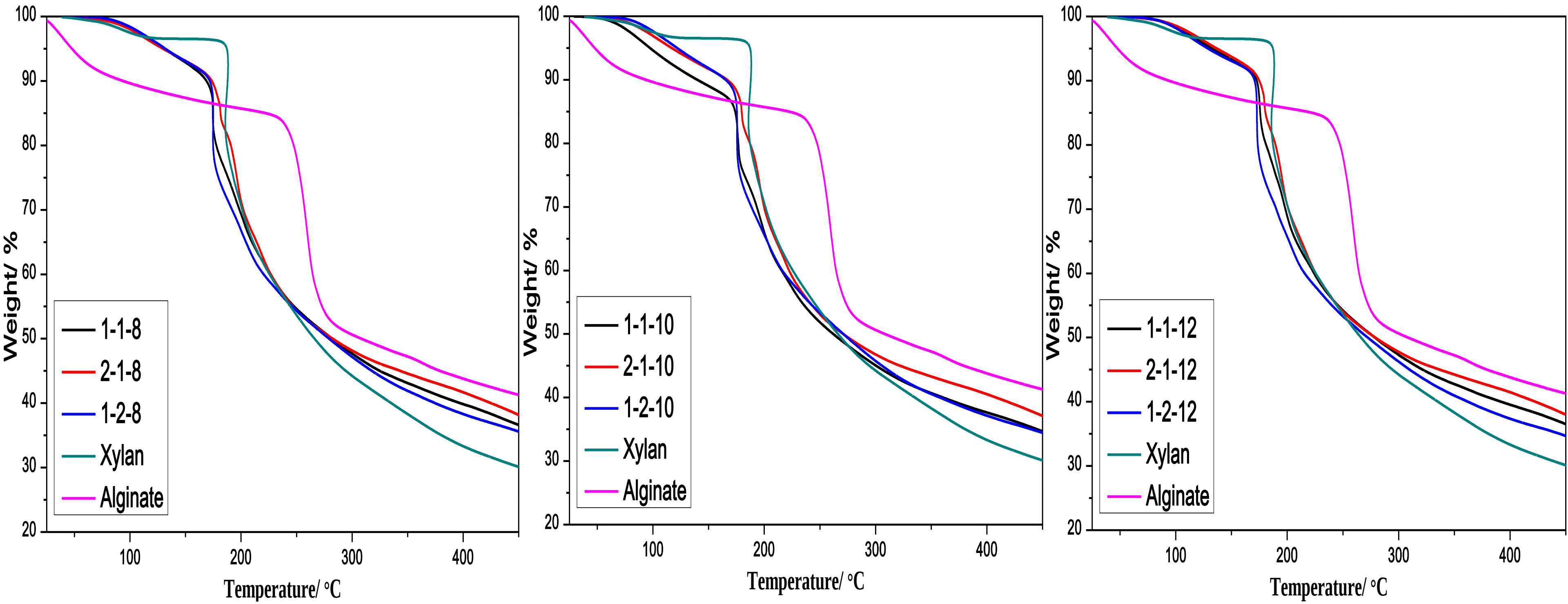

Figure 7: Thermograms of (a) films containing 8% glycerol, (b) films containing 10% glycerol and (c) films containing 12% glycerol.

TGA continued

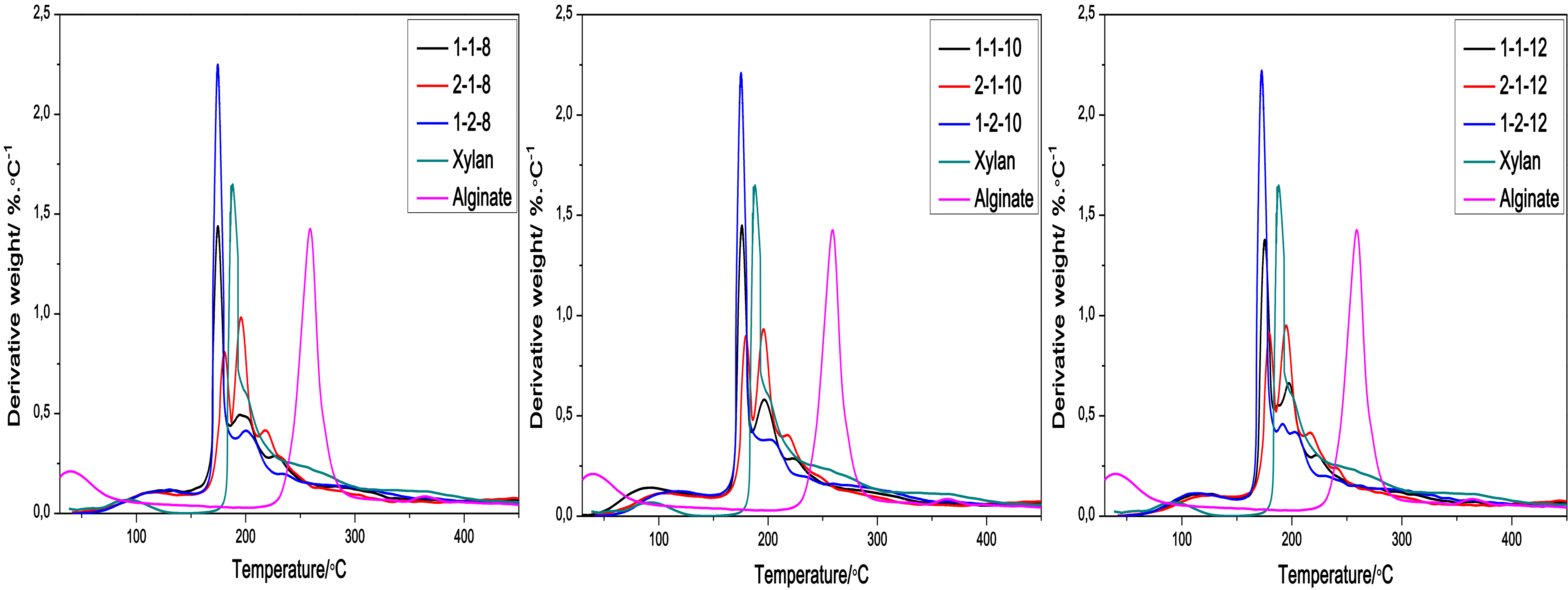

Figure 8: Derivative thermograms of (a) films containing 8% glycerol, (b) films containing 10% glycerol and (c) films containing 12% glycerol.

Water vapour transmission rate

Table 2: WVTR of alginate and xylan blend films

Sample	WVTR/ g.h^{-1}.m^{-2}
1-2-8 Al-Xyl-Gly	0,30 ± 0,012
1-1-8 Al-Xyl-Gly	0,34 ± 0,090
2-1-8 Al-Xyl-Gly	0,89 ± 0,079
1-2-10 Al-Xyl-Gly	0,55 ± 0,012
1-1-10 Al-Xyl-Gly	0,59± 0,048
2-1-10 Al-Xyl-Gly	0,75 ± 0,072
1-2-12 Al-Xyl-Gly	0,61 ± 0,041
1-1-12 Al-Xyl-Gly	0,63 ± 0,041
2-1-12 Al-Xyl-Gly	0,79 ± 0,034

Water sorption

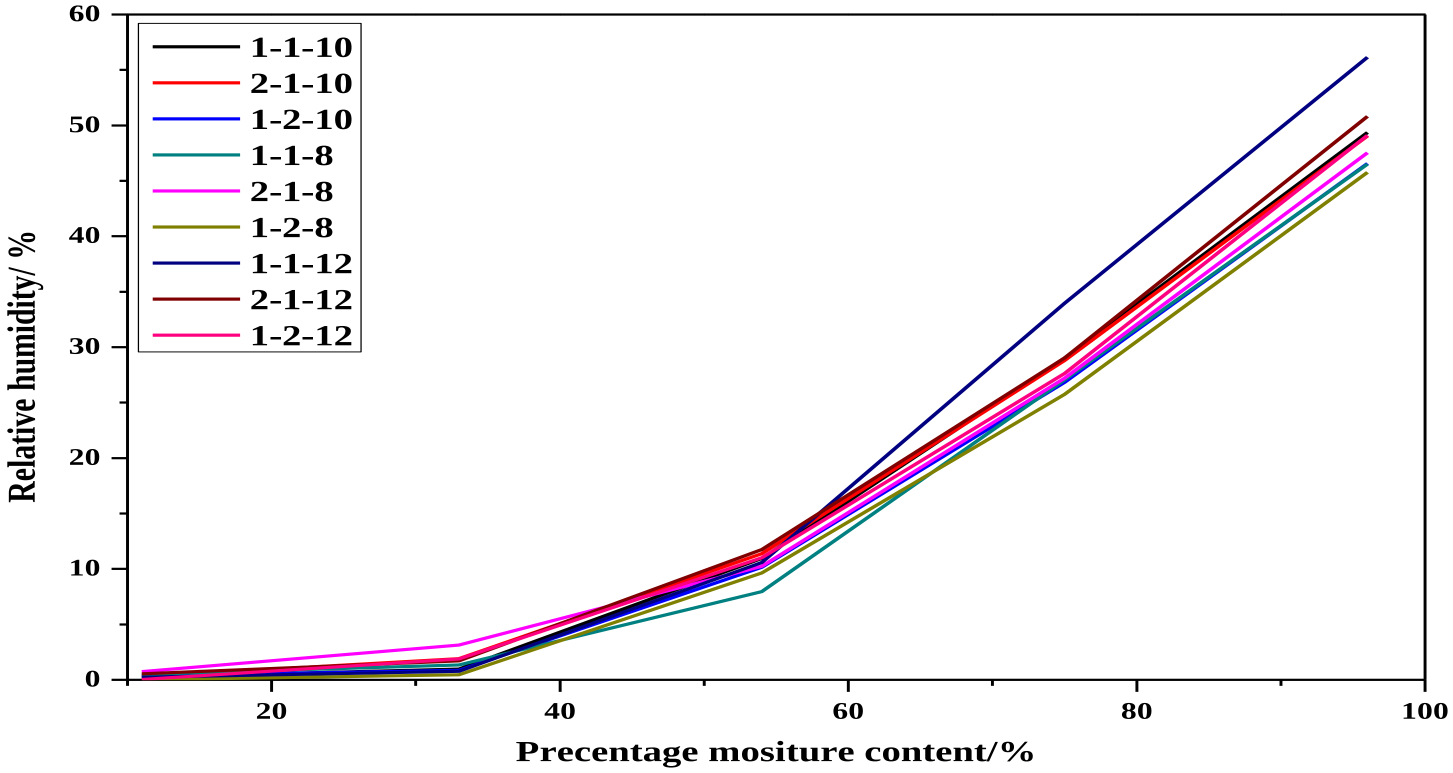

Figure 8: Water sorption isotherm of alginate and xylan films

Comparison Mechanical Properties

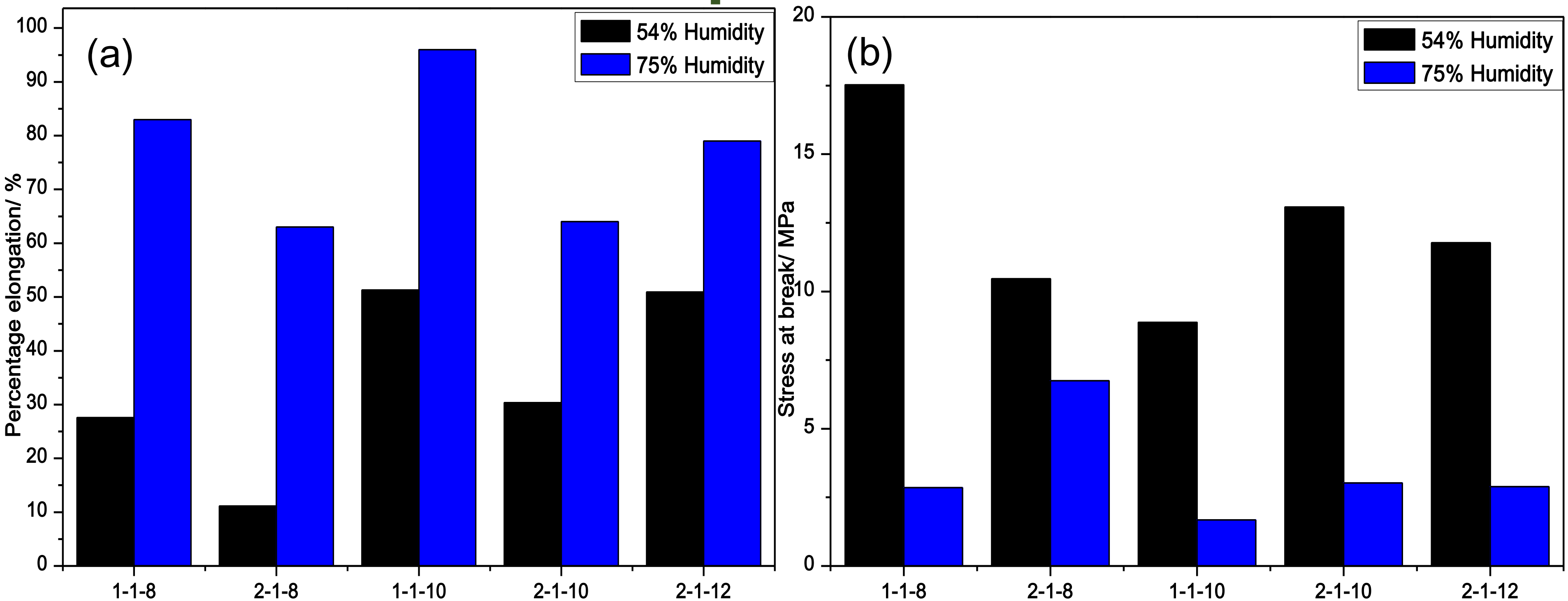

Figure 9: (a) Elongation at break of alginate and xylan blends at different humidities and (b) stress at break of alginate and xylan blends at different humidities.

Conclusions

- Alginate and xylan films were successfully prepared
- The 1-1-10 film had the best mechanical properties
- The films became more yellow with increased alginate
- An increase in humidity will decrease tensile strength and increased elongation at break

Funding

- Thank you to the DST Waste RDI roadmap for funding my project

- CSIR Polymer and Composites competence area

Thank you for your attention

Any questions

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