Dynamic and Mechanical Properties of Agro-fiber Based Composites

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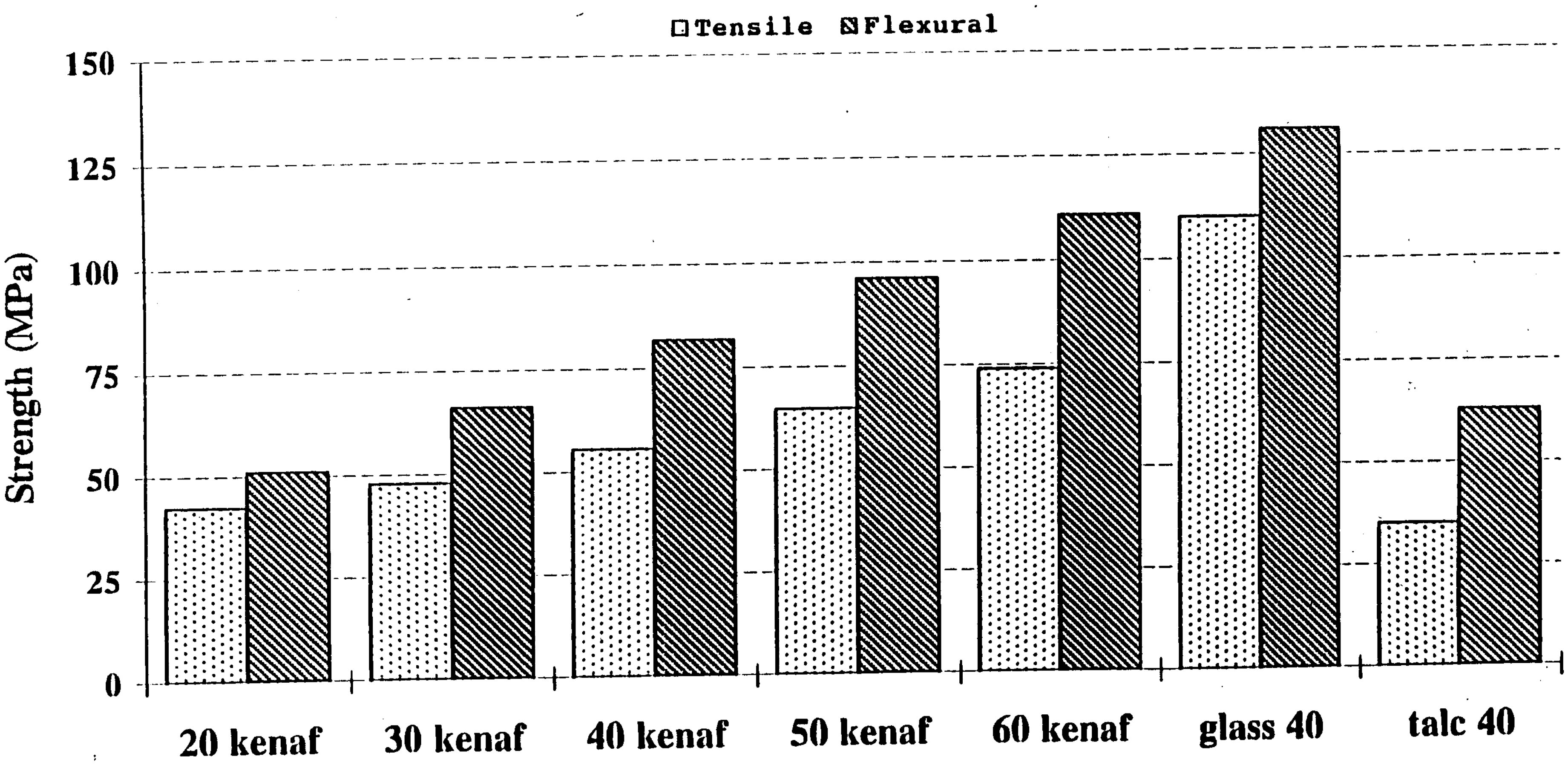
Abstract

Although lignocellulosic, fiber-thermoplastics composites have been used for several decades, recent economic and environmental advantages have resulted in significant commercial inteterest in the use of these fibers for several applications. Kenaf is a fast growing annual growth plant that is harvested for its bast fibers. These fibers have excellent specific properties and have potential to be outstanding reinforcing fillers in plastics. The modulus and strength of kenaf-PP compatibilized composites increase significantly with the addition of the kenaf fibers and some comparisons with conventional composites are presented. Although the strength of the composites are lower than typical glass composites, the modulus of the highly loaded kenaf composites are comparable to glass fiber composites. The kenaf composites also have the added advantage of being reprocessed without significant loss in properties, which is unlikely in case of glass composites.

This paper also reports the structure-property relationships of using compatibilizers and PP impact copolymers in lignocellulose-PP composites. Dynamic Properties will also be reported giving insights into the mechanical response of the composites at different temperatures, creep behavior and some insights into the structure-property relationships of the composites. The dynamic mechanical properties are affected by the amount of fiber in the composite and also the addition of coupling agents. Due to the better adhesion between the polymer matrix and kenaf fibers, the coupled blends have better high temperature modulus and higher softening temperatures than the uncoupled blends. The creep properties also improved by coupling agent. The coupled blends have a lower creep compliance than the uncoupled blends indicating a better dimension stability: inspite of a lower creep compliance the melting temperatures of coupled samples are lower than that of uncoupled samples. This may indicate that the coupled blends have more defects in the polymer crystals.

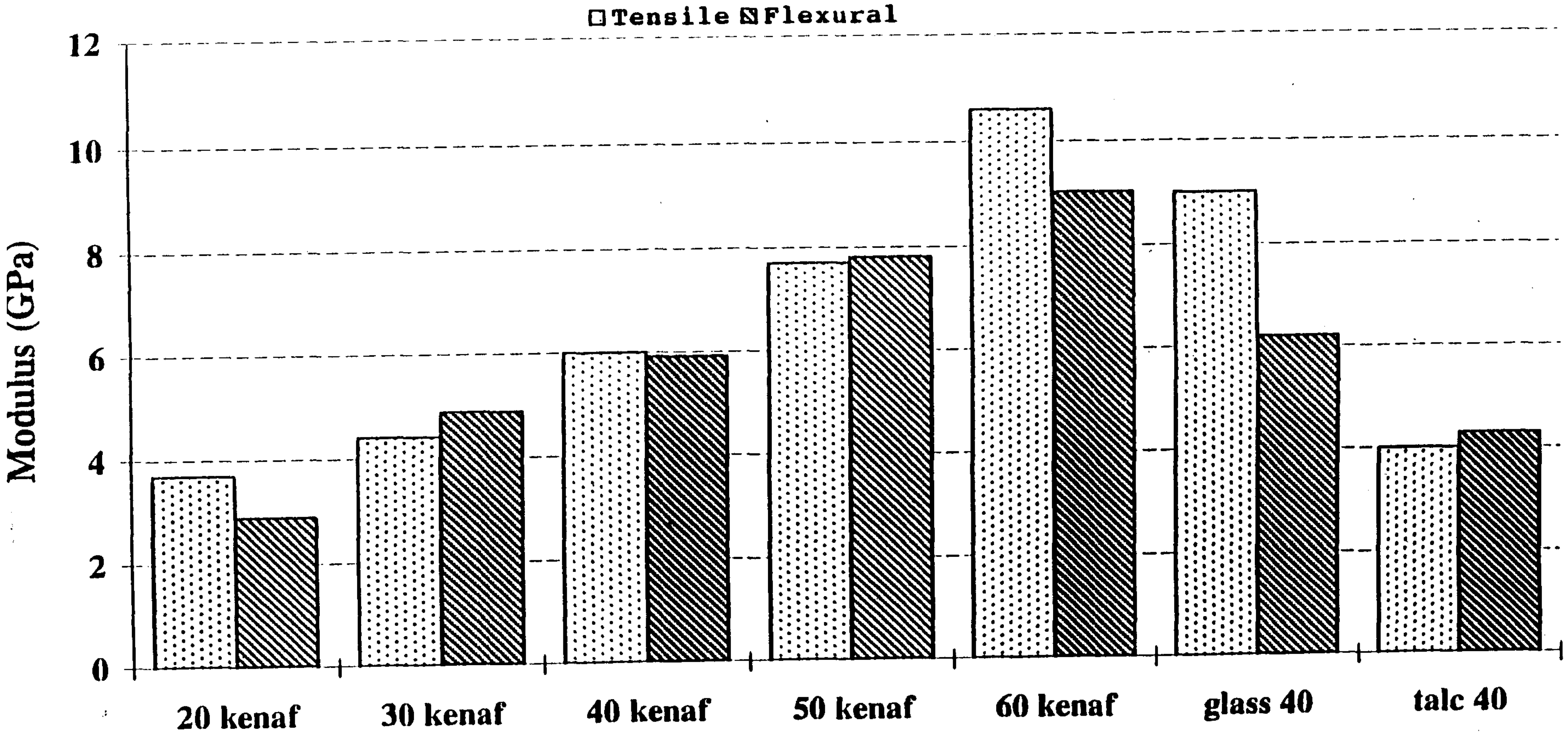
KENAF	Tensile Strength	Tensile Modulus	Tensile Failure Strain	Flexural Strength	Flexural Modulus	Izod notched	Izod unnotch-ed
40 coupled PP	55.8	6	2.36	81.8	5.91	28.27	157.3
50 uncoupled PP	33.3	9.3	1.1	55.2	8.03	33.92	87.56
50 coupled PP	65.8	8.3	1.82	98.1	7.3	36.65	167.51
50 uncoupled PE	11.89	4.57	1.01	18.41	2.13	57.9	81.2
50 coupled PE	26.52	3	3.1	33.11	2.12	109.8	252.8

Effect of Fiber Content (wt.%) on Composite Strength



Glass and talc data obtained from various sources

Effect of Fiber Content (wt.%) on Composite Modulus



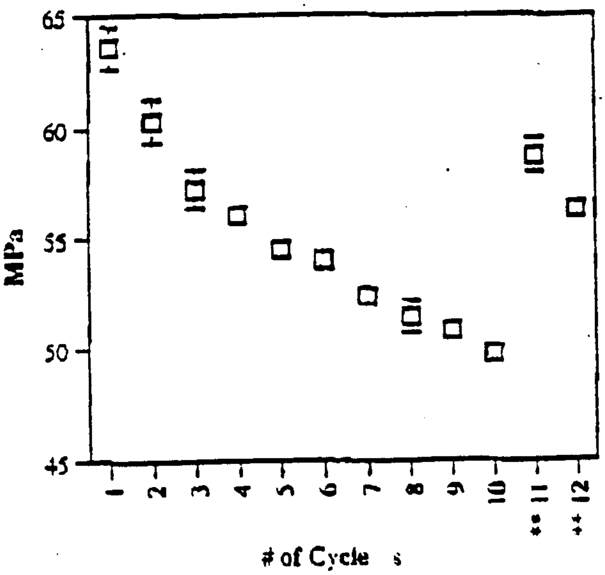
Glass and Talc data obtained from various sources

Table 1 Comparison of Properties of Kenaf-Filled PP with Commercially Filled Polypropylenes.

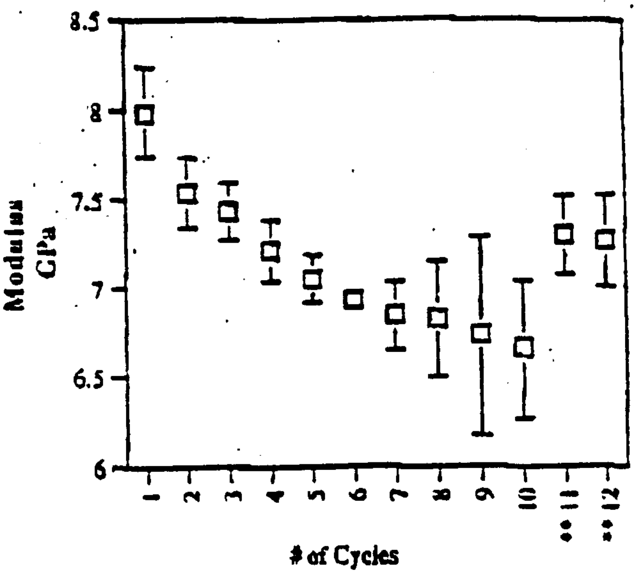
Filler/Reinforcement	none**	kenaf**	ONP**	TALC	CaCO3	Glass *	Mica
% filler by weight	0	50	40	40	40	40	40
% filler by volume	0	40	32	18	18	19	18
Tensile Modulus, GPa	1.7	7.7	4.4	4	3.5	9	7.6
Specific Tensile Modulus, GPa	1.9	7.2	4.5	3.1	2.8	7.3	6.0
Tensile Strength, MPa	33	62	53	35	25	110	39
Specific Tensile Strength, MPa	37	58	54	28	20	89	31
Elongation at Break, %	>>10	2.2	3	X	X	2.5	2.3
Flex Strength, MPa	41	91	80	63	48	131	62
Specific Flex. Strength, MPa	46	85	82	50	38	107	49
Flex. Modulus, GPa	1.4	7.8	3.9	4.3	3.1	6.2	6.9
Specific Flex. Modulus, GPa	1.6	7.3	4.0	3.4	2.5	5.0	5.5
Notched Izod Impact- J/m	24	32	21	32	32	107	27
Specific Gravity	0.9	1.07	0.98	1.27	1.25	1.23	1.26
Water Absorption %- 24 hr	0.02	0.95	0.57	0.02	0.02	0.06	0.03

** Experimental work at UW and FPL.....* chemically coupled glass fibers ...... ONP is recycled newspaper
Data for talc/CaCO3 from Modern Plastics Encyclopedia,1989, for glass/mica from Materials Selector, 1993.

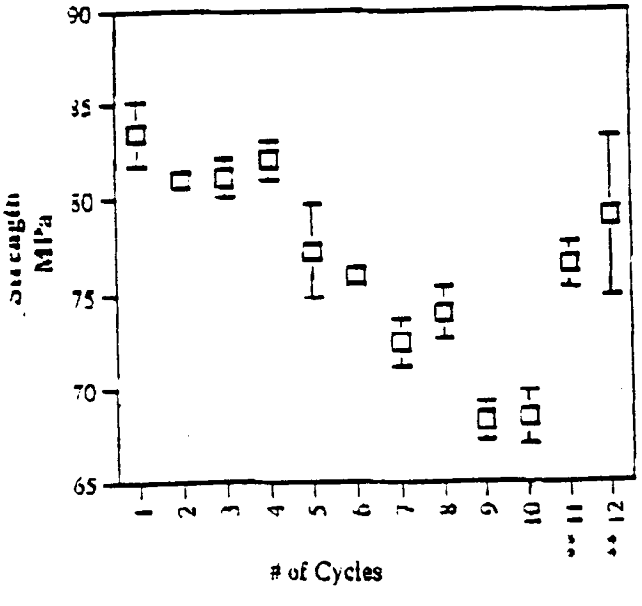
Tensile Strength Vs. # of Processing Cycles



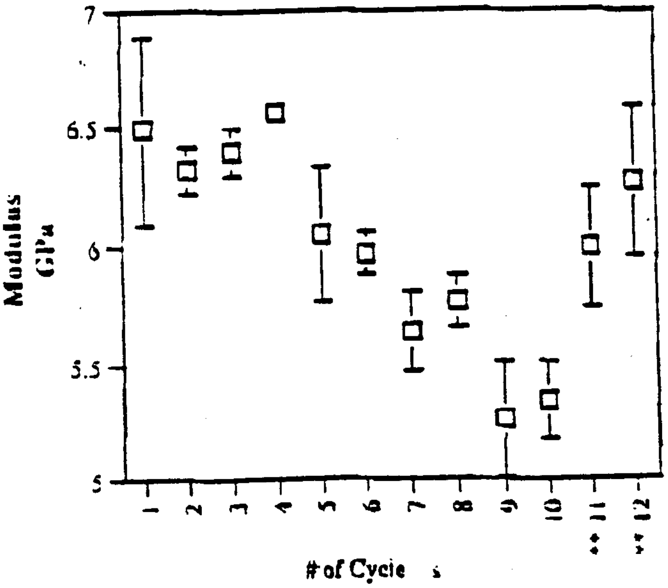
Tensile Modulus Vs. # of Processing Cycles



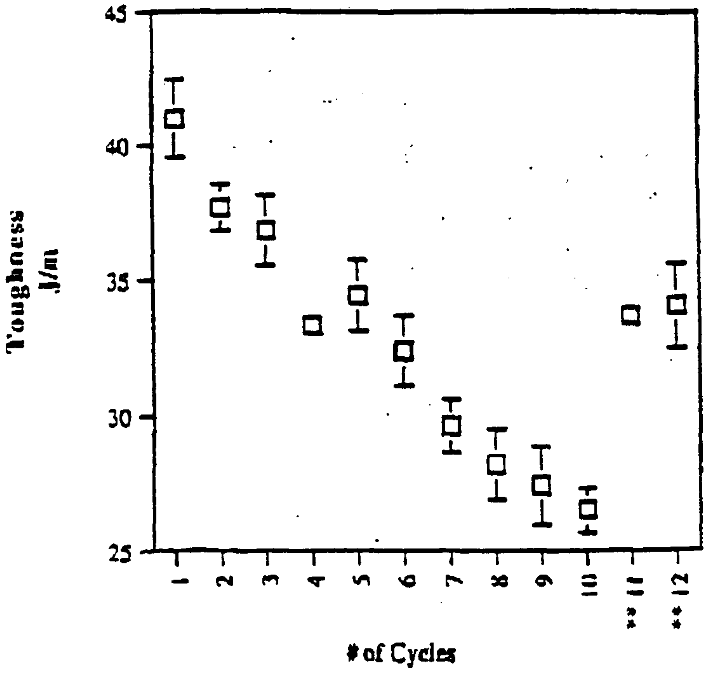
Flexural Strength Vs. # of Processing Cycles



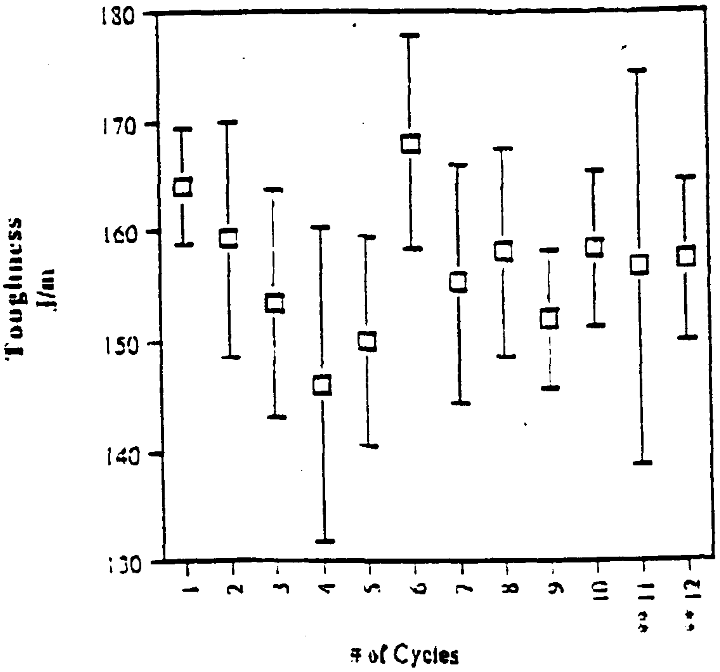
Flexural Modulus Vs. # of Processing Cycles



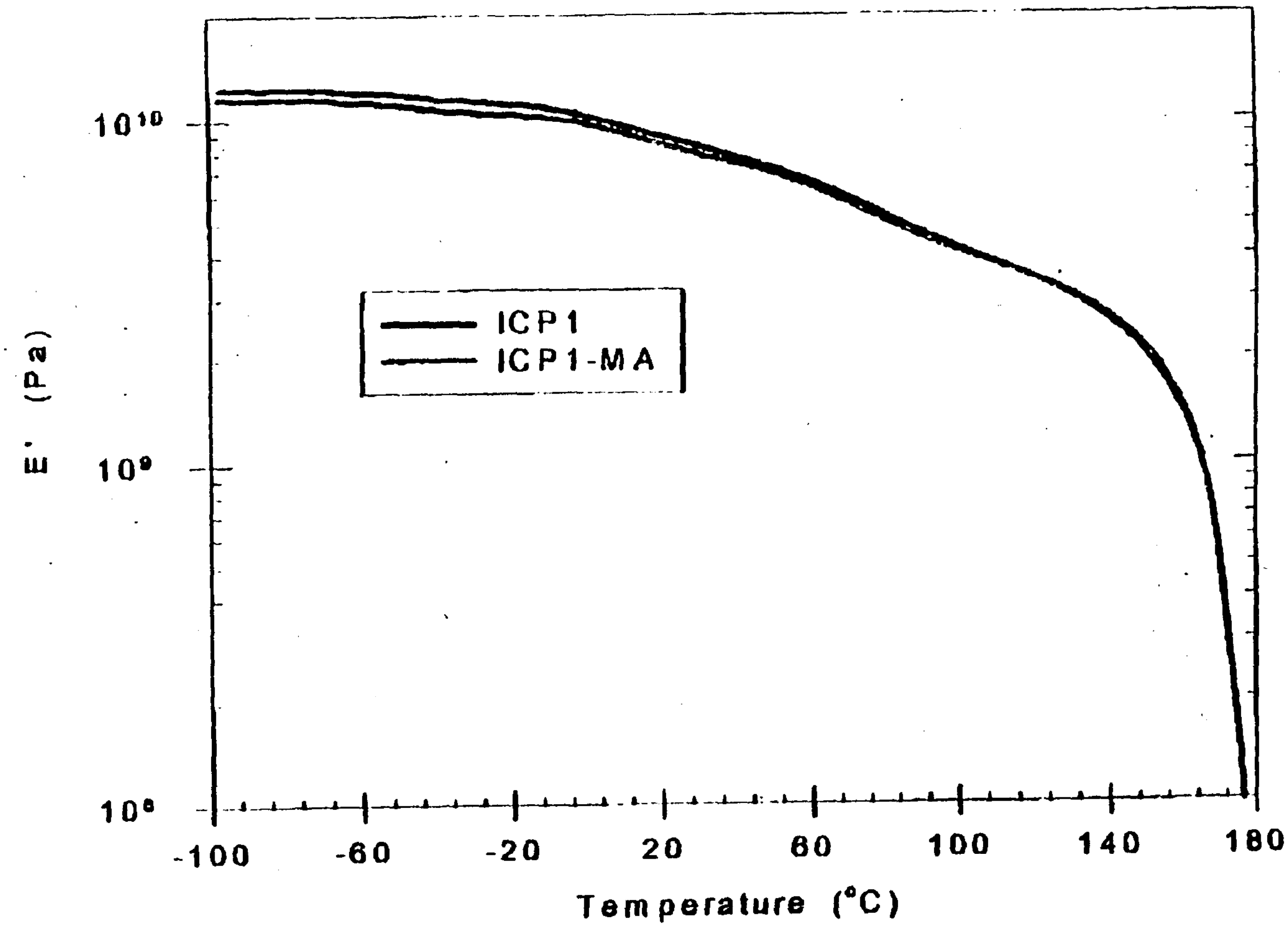
Notched Izod Impact Toughness Vs. # of Processing Cycles



Unotched Izod Impact Toughness Vs. # of Processing Cycles



DMA E' of ICP1/kenaf blends



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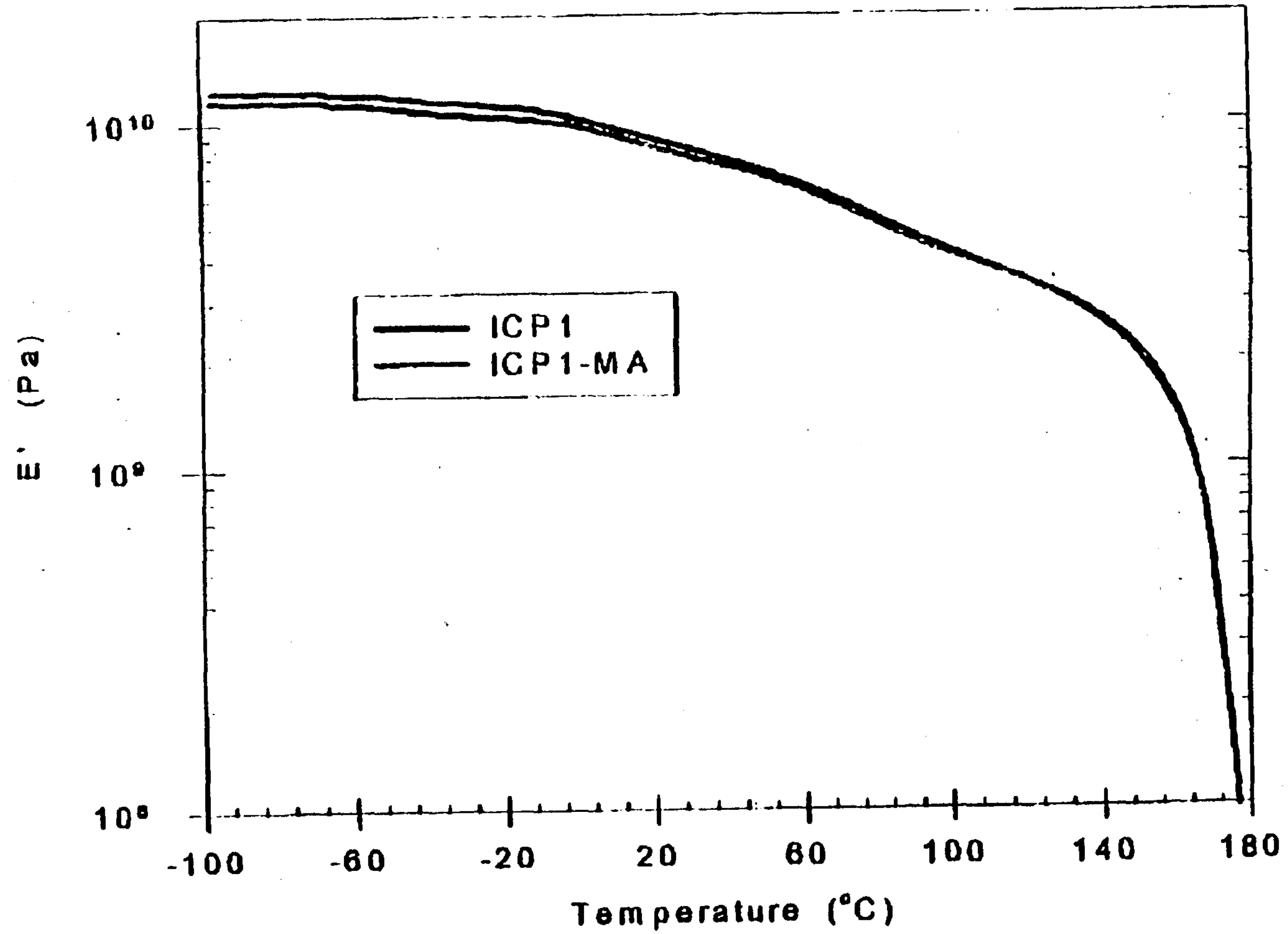
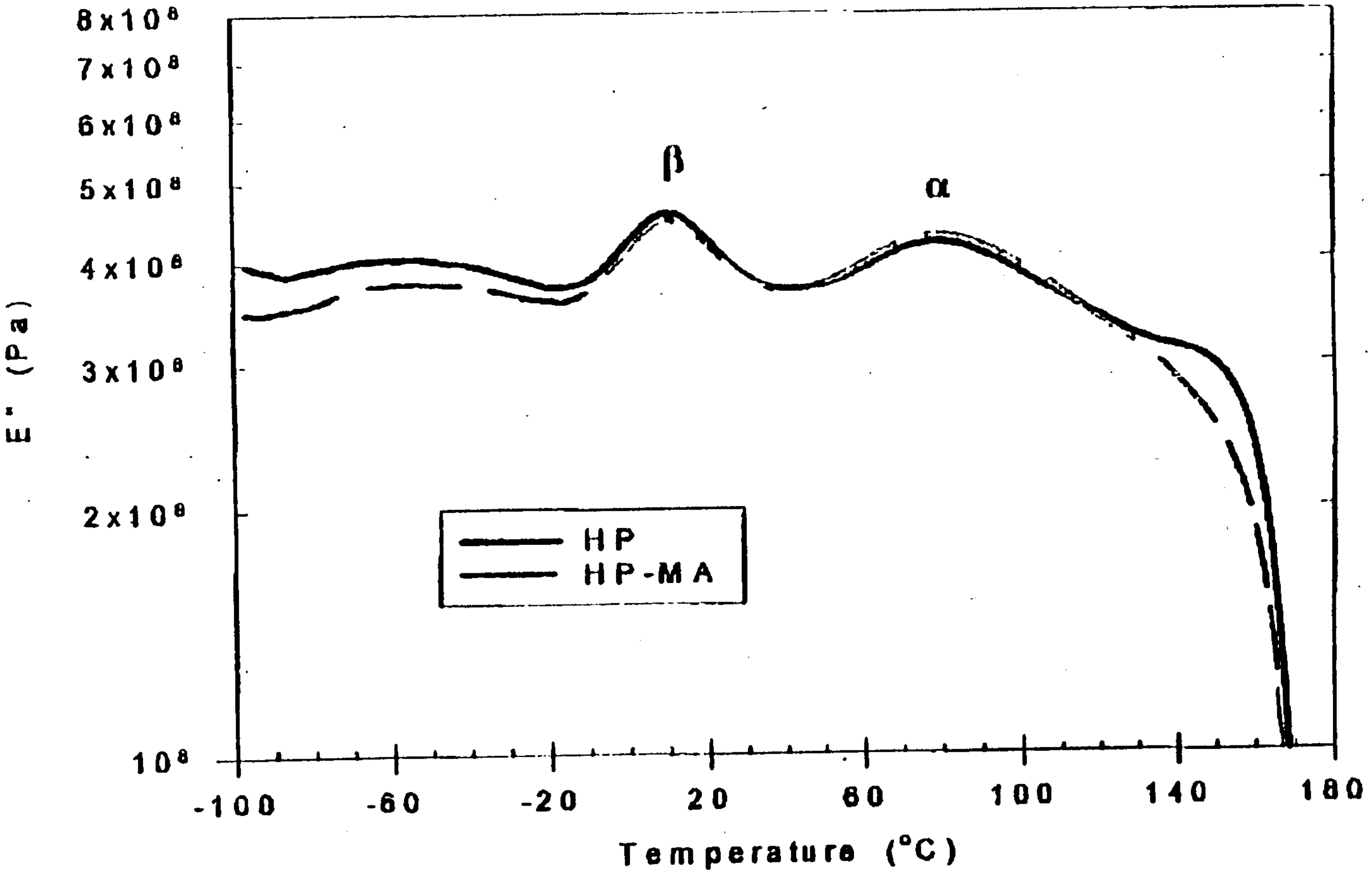
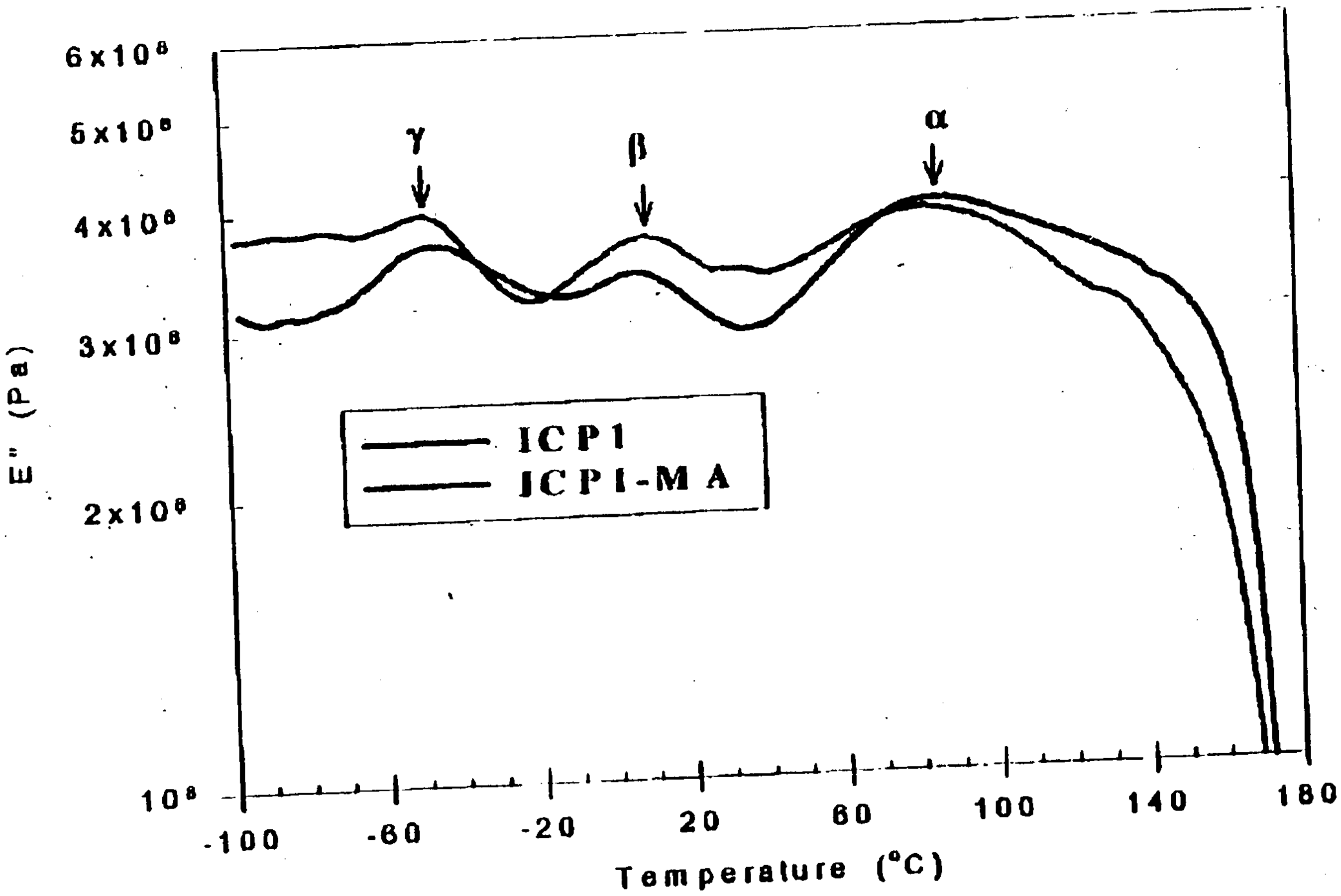


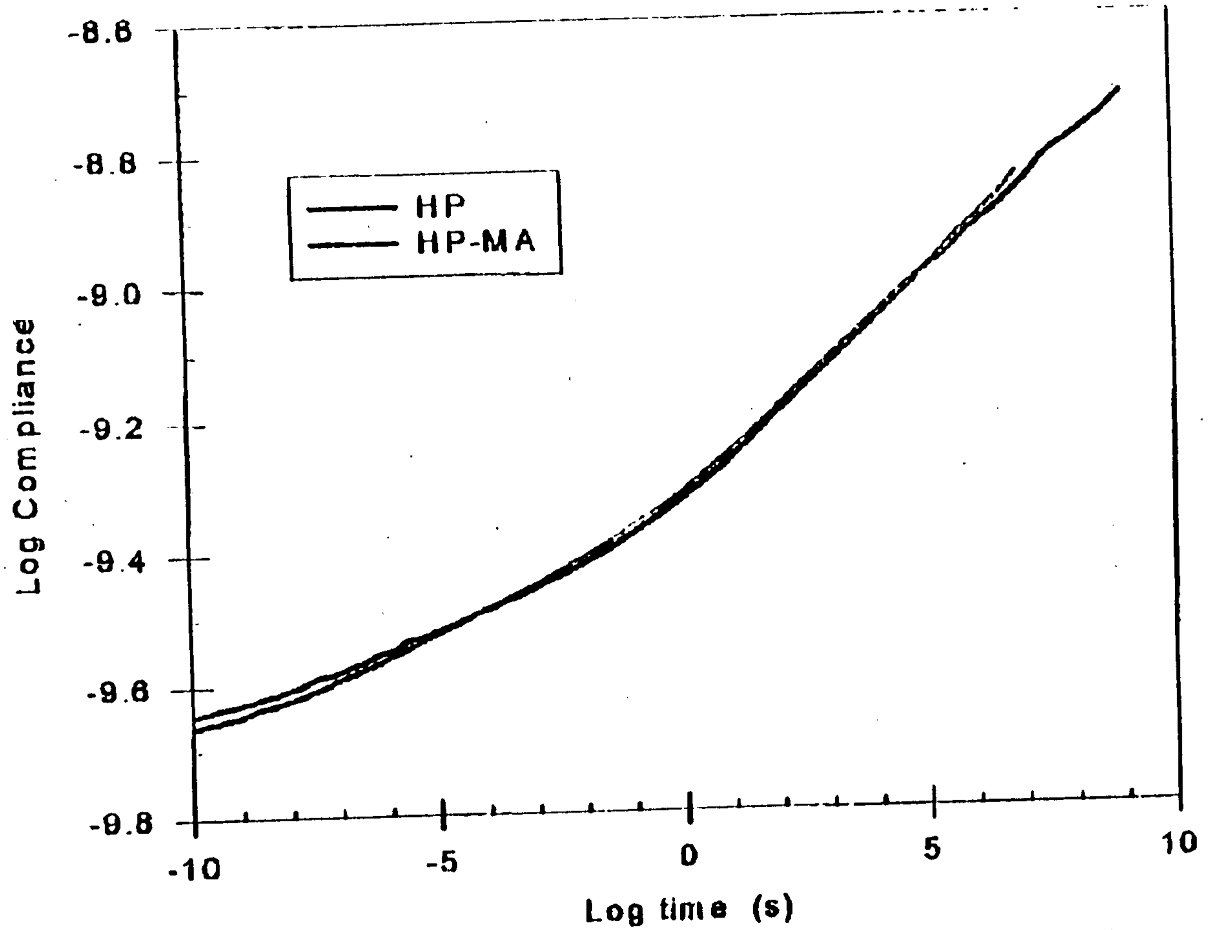
DMA E" of HP/kenaf blends



DMA E'' of ICP1/kenaf blends



Creep behavior of HP/kenaf blends



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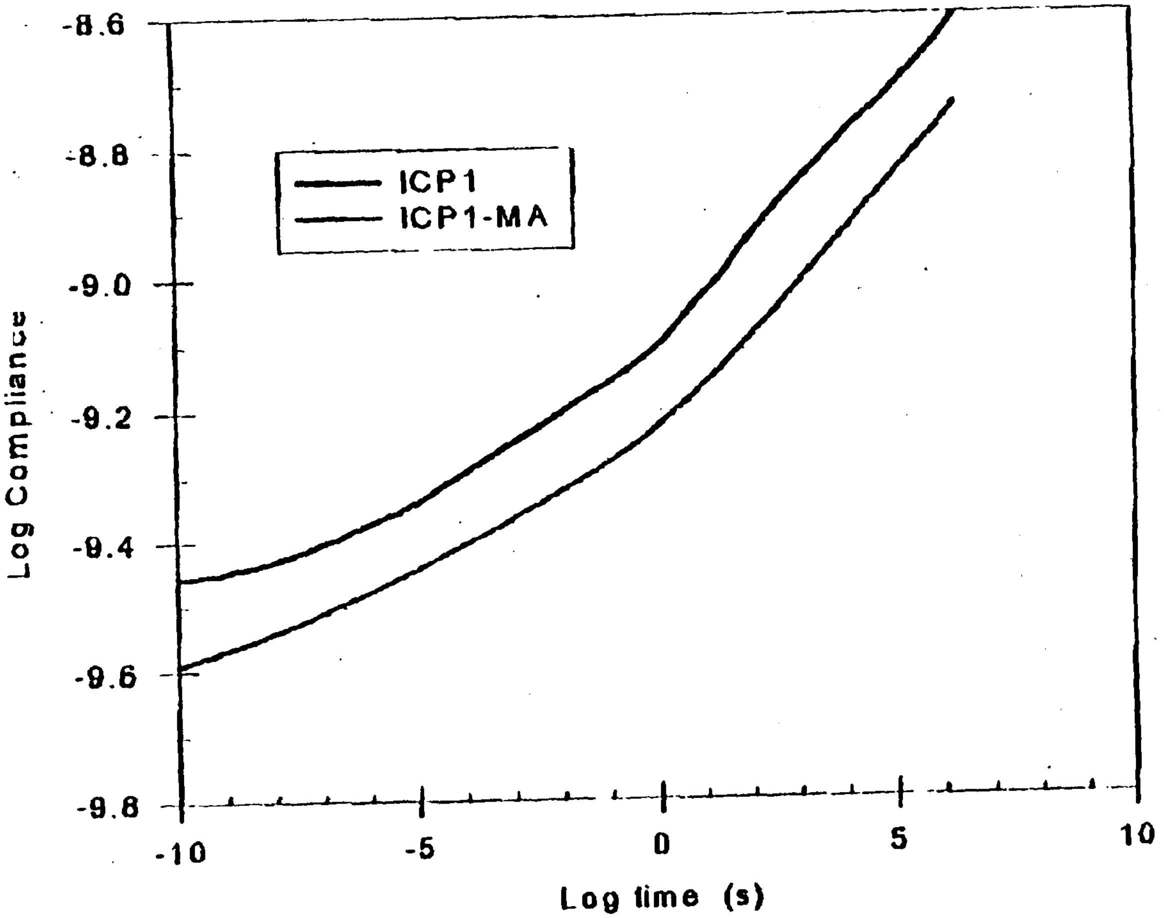

DMTA

0, 20%, 40%, 60% KENAF PP
1602 HOMOPOLYMER

Head: Combined 500°C

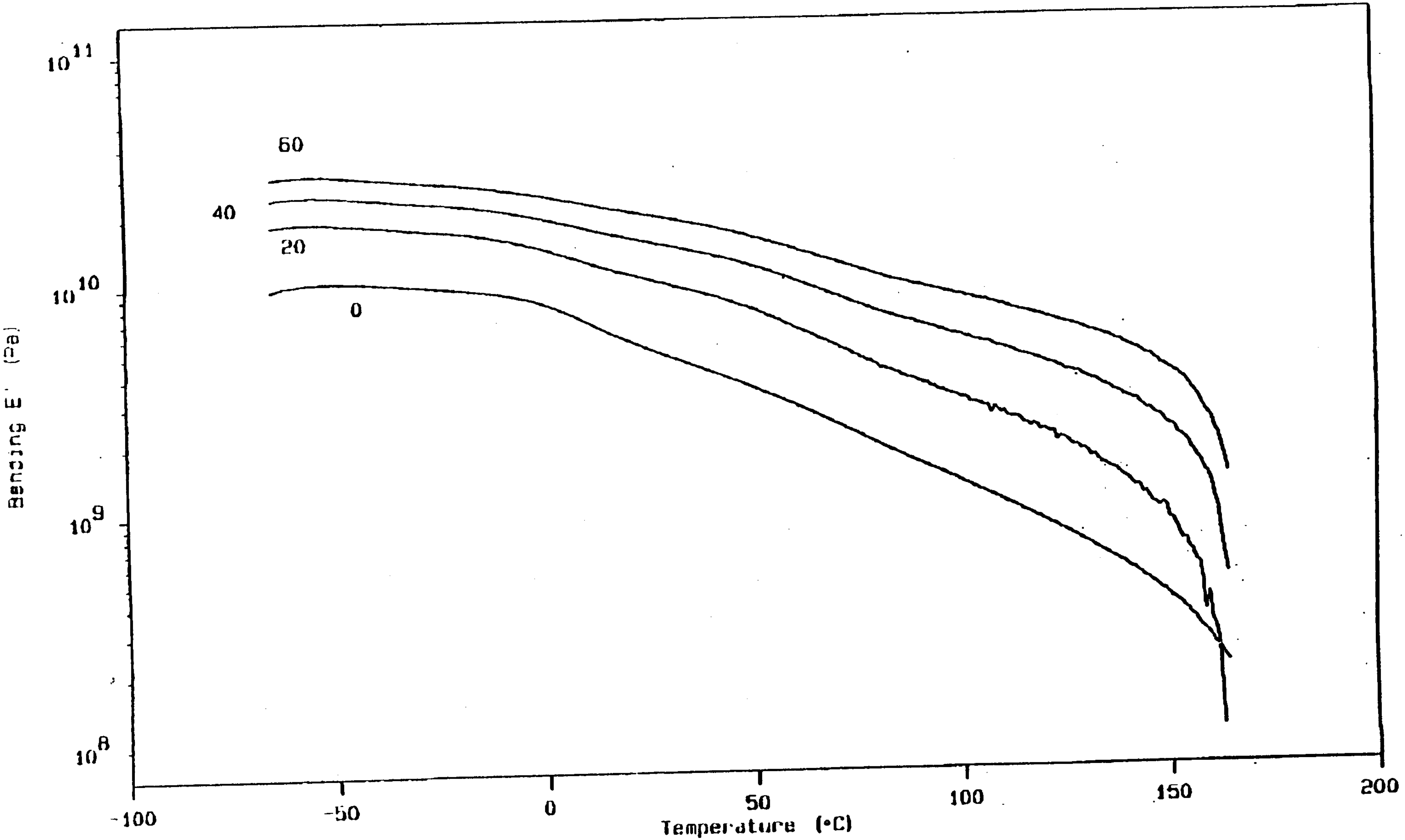

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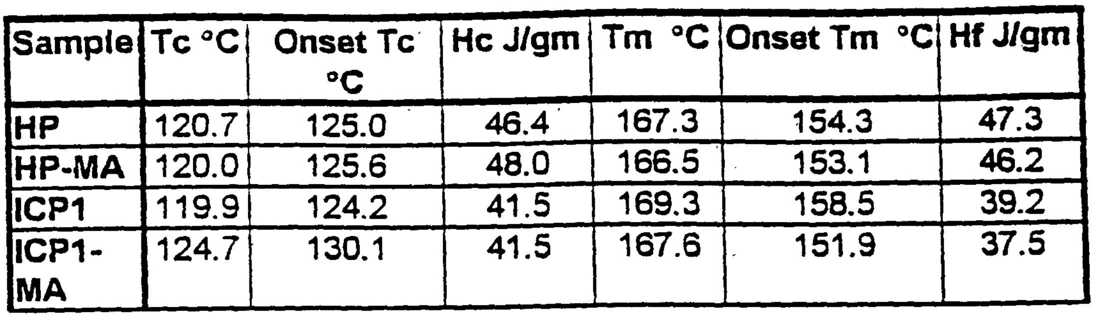
Table I. Composition of PP/kenaf fiber blends.

Sample ID	Polymer Type	Polymer MFR g/10 min	Polymer wt%	Kenaf Fiber wt%	Coupling Agent wt%
HP	Solvay 1602	12	50	50	0
HP-Ma	Solvay 1602	12	47	50	3
ICP1	Amoco 3143	2.5	50	50	0
ICP1-Ma	Amoco 3143	2.5	47	50	3

Table II. Mechanical properties of PP/Kenaf fiber blends.

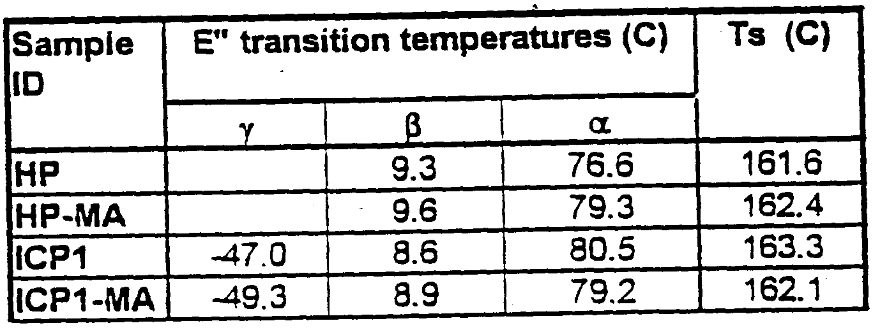
Sample ID	Izod (J/m)		Tensile Strength (Map)	Tensile Modulus (GPa)	Failure Strain %
	Notched	UN-notch			
HP	33.90	87.60	33.30	9.30	1.10
HP-MA	36.70	167.50	65.80	8.30	1.82
ICP1	41.30	76.30	25.60	12.99	0.94
ICP1-MA	74.30	211.95	52.50	7.45	2.48

Table III. Thermal properties of PP/kenaf fiber blends.



Sample	Tc °C	Onset Tc °C	Hc J/gm	Tm °C	Onset Tm °C	Hf J/gm
HP	120.7	125.0	46.4	167.3	154.3	47.3
HP-MA	120.0	125.6	48.0	166.5	153.1	46.2
ICP1	119.9	124.2	41.5	169.3	158.5	39.2
ICP1-MA	124.7	130.1	41.5	167.6	151.9	37.5

Table IV. DMA transition temperatures of PP/Kenaf fiber blends.



Sample ID	E" transition temperatures (C)			Ts (C)
	γ	β	α	
HP		9.3	76.6	161.6
HP-MA		9.6	79.3	162.4
ICP1	-47.0	8.6	80.5	163.3
ICP1-MA	-49.3	8.9	79.2	162.1

PROGRESS IN WOODFIBRE-PLASTIC COMPOSITES:

Emergence of a New Industry

Presentations at a One-Day Workshop
Days Inn
Mississauga, Ontario
June 1, 1998

Editors
John J. Balatinecz
Faculty of Forestry
University of Toronto
and
Tony E. Redpath
MMO

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Agenda

8 a.m. Registration and Continental Breakfast

8:45 Opening Remarks
Grant Allan, President & C.E.O
Materials and Manufacturing Ontario

9:00 **Session 1: Progress in R&D**

Moderator: John Youngquist, USDA Forest Products Laboratory

"Progress in the chemistry of surface compatibility" Michael Brook, McMaster University

"Dynamic fracture toughness of woodfibre-plastic composites" Craig Clemons, USDA Forest Products Laboratory

"Control of impact strength in wood-fibre-reinforced polymers" Mark Kortschot, University of Toronto

10:30 Coffee and Telephone Time

10:45 **Session 2: Progress in processing and properties**

Moderator: Tony Redpath, MMO

"Dynamic mechanical properties of agri-fibre based composites" Anand Sanadi, University of Wisconsin

"Properties and applications of HDF composites" Shujjat Ahmed, Matrix Composites Inc.

"Advances in profile extrusion of woodfibre-plastic composites" Brad Lamone, Crane Plastics Co.

12:15 Break

12:30 Luncheon with keynote speaker
Brent English, North Wood Plastics Inc.

2 p.m. **Session 3: Industrial panel - Progress in manufacturing and marketing: the road ahead.**

Moderator: Peter McGeer, MMO

"Producing non-structural building components" Herbert Hoedl, Royal Ecoproducts Inc.

"Producing high performance composites for pallets" Weining Song, Dura-Products Inc.

"Extruding composite sheets" Ken Macleod, New City Resources Inc.

"Profile extrusion of woodfibre plastic composites for various market applications" Dedo Suwanda, CRF Technologies Inc.

3:45 **Session 4: Poster presentations and commercial exhibits**

5:00 Wine and hors d'oeuvres

Workshop Organizers

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