

Stiff-Elongated Balance of PLA-Based Polymer Blends

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1. Results

1.1. Binary Blends

The design of experiments was done through MINITAB-17 software. For the formulation of the binary polymer blends, a full factorial experiment model 2^k was applied. Three distinct factors, polymer, concentration, and mixing time were defined; see Table S1.

Table S1. Levels and factors considered in the factorial experiment model 2k.

Factor	Description	Polymer Blends with Elongation Capacity		Stiff Polymer Blends	
		Low Level (-1)	High Level (+1)	Low Level (-1)	High Level (+1)
A	Polymer	LDPE	EVA	PS	Poly(S-co-MMA)
B	Concentration	1%	30%	1%	30%
C	Mixing time	5 min	15 min	5 min	15 min

Table S2. Factorial regression for polymer blends with elongation capacity.

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F Value	p Value
Model	4	565.61	141.403	14.61	0.000
Linear	3	551.46	183.819	18.99	0.000
A	1	219.90	219.899	22.71	0.000
B	1	291.19	291.186	30.08	0.000
C	1	40.37	40.370	4.17	0.055
2-Way Interactions	1	14.16	14.157	1.46	0.241
A*B	1	14.16	14.157	1.46	0.241
Error	19	183.94	9.681		
Lack-of-Fit	3	15.70	5.233	0.50	0.689
Pure Error	16	168.25	10.515		
Total	23	749.56			

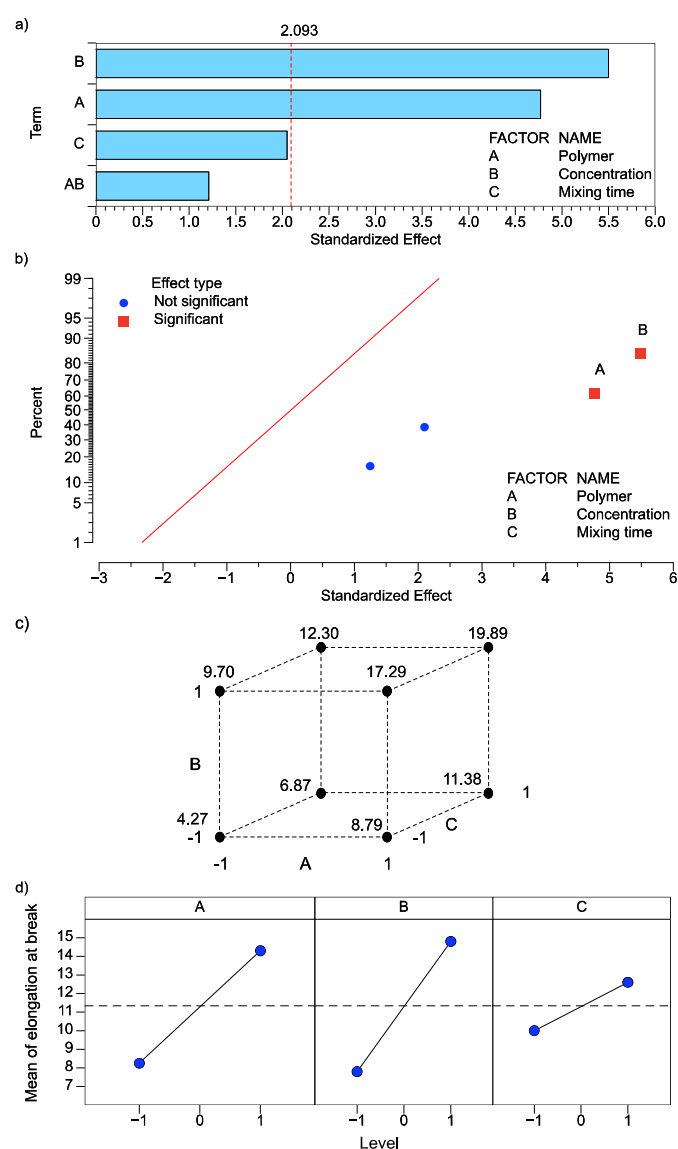


Figure S1. (a) Pareto chart of standardized effects for $\alpha = 0.05$, (b) Normal chart, (c) Cube plot, and (d) Main effects of elongation.

Table S3. Conditions for formulating polymer blends with elongation capacity.

Factor	Name	Level	Identification
A	Polymer	(+1)	EVA
B	Concentration	(+1)	30%
C	Mixing time	(-1),(+1)	5 min and 15 min

Table S4. Factorial regression for stiff polymer blends.

Analysis of Variance					
Source	DF	Adj SS	Adj MS	Valor F	Valor P
Model	7	0.126396	0.018057	3.30	0.023
Linear	3	0.084155	0.028052	5.03	0.012
A	1	0.024067	0.024067	5.26	0.036
B	1	0.000088	0.000088	0.01	0.934
C	1	0.060000	0.060000	9.81	0.006
2-Way Interactions	3	0.011568	0.003856	0.46	0.712

A*B	1	0.000400	0.000400	0.01	0.922
A*C	1	0.003174	0.003174	0.35	0.560
B*C	1	0.007993	0.007993	1.02	0.326
3-Way Interactions	1	0.030674	0.030674	6.61	0.021
A*B*C	1	0.030674	0.03674	6.61	0.021
Error	16	0.094434	0.005902		
Total	23	0.220830			

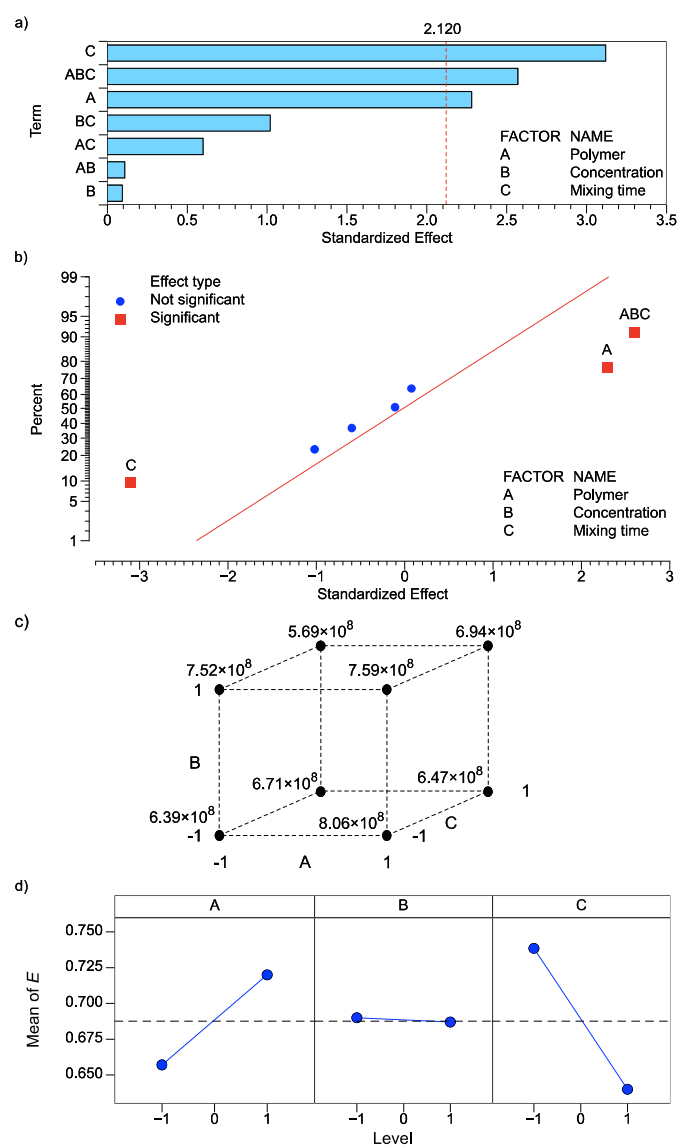


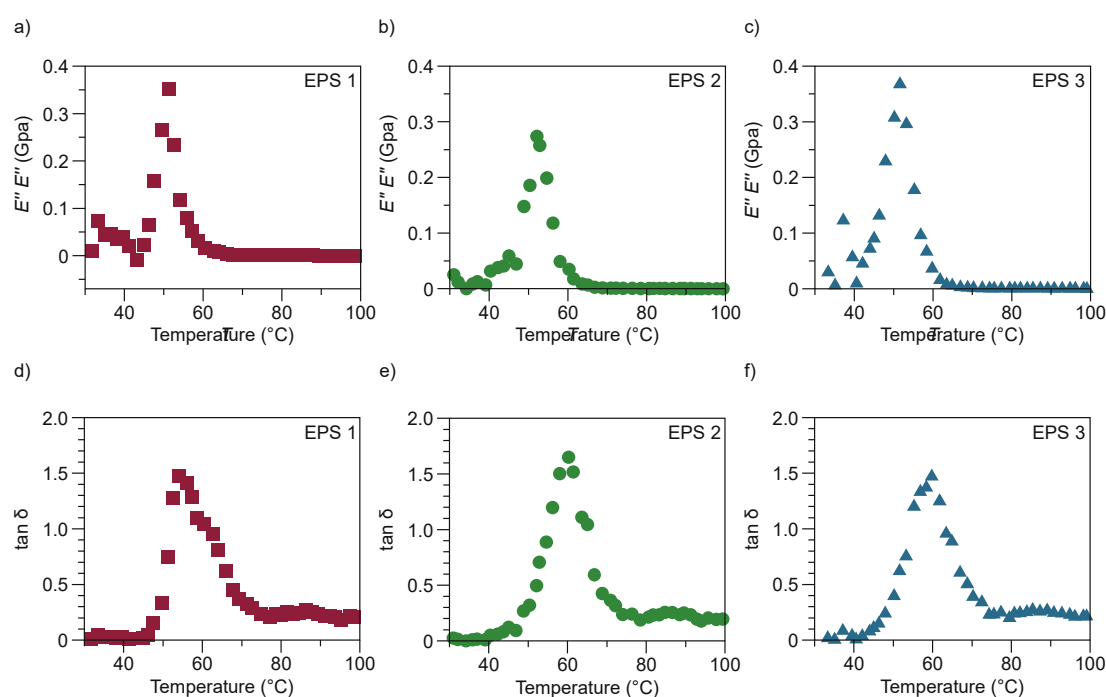
Figure S2. (a) Pareto chart of standardized effects (response elastic modulus), (b) Normal chart, (c) Cube plot, and (d) Main effects for elastic modulus.

Table S5. Conditions of high stiffness blends are considered to continue with characterization.

Factor	Name	Level	Identification
A	Polymer	(+1)	SMMA
B	Concentration	(-1),(+1)	1% and 30%
C	Mixing time	(-1)	5 min

Table S6. Mechanical and physicochemical properties of neat PLA/5 min, neat PLA/15 min, binary and ternary blends.

Sample	ϵ_b / %	E / GPa	E' / GPa Glassy ¹	E' / GPa Rubbery ¹	T_{g1} / °C	T_{g2} / °C	$\tan \delta$
EPS 1	21.24 ± 5.1	0.63 ± 0.04	1.50	0.003		51.2	1.37
EPS 2	43.78 ± 6.7	0.63 ± 0.06	0.79	0.002		52.5	1.65
EPS 3	67.13 ± 9.4	0.57 ± 0.03	1.47	0.002		51.6	1.47
70PLA-30EVA/t5	18.1 ± 4.8	0.29 ± 0.01	1.28	0.001	−32.52	54.82	1.6
70PLA-30EVA/t15	19.0 ± 8.5	0.43 ± 0.03	1.62	0.0011	−36.41	55.07	1.56
99PLA-1SMMA/t5	-	0.81 ± 0.13	3.01	0.0025		57.4	2.1
99PLA-1SMMA/t15	-	0.65 ± 0.05	3.25	0.0027		58.2	2.1
Neat PLA/t5	5.30 ± 1.3	0.50 ± 0.09	2.85	0.002		56.3	3.05
Neat PLA/t15	4.70 ± 0.1	0.62 ± 0.04	3.01	0.002		51.6	2.69

¹ Measurement made at 37 °C and 80 °C for the glassy and rubbery zone, respectively.**Figure S3.** Loss modulus of ternary blends. (a) EPS 1, (b) EPS 2, (c) EPS 3; and $\tan \delta$ of ternary blends, (d) EPS 1, (e) EPS 2, (f) EPS 3.**Table S7.** TGA parameters (T_{onset} , T_{max} , and T_i) in EVA, PLA, SMMA, and EPS ternary blends.

Sample	First Degradation Step (T_{d1})			Second Degradation Step (T_{d2})			Third Degradation Step (T_{d3})		
	T_{onset} / °C	T_{max} / °C	T_i / °C	T_{onset} / °C	T_{max} / °C	T_i / °C	T_{onset} / °C	T_{max} / °C	T_i / °C
neat PLA / t15	223	298	253	-	-	-	-	-	-
neat EVA / t15	292	344	388	423	452	489	489	503	527
neat SMMA / t15	261	402	439	-	-	-	-	-	-
EPS 1	240	328	387	399	461	480	480	491	529
EPS 2	260	326	383	408	443	484	484	490	519
EPS 3	250	330	388	410	438	477	477	490	529