Preparation of TPE from Devulcanized Rubber Crumbs

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Background

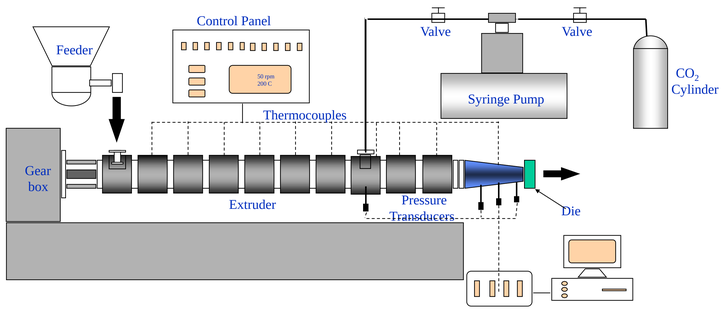
- Devulcanization of waste rubber with $scCO_2$ in an extruder is an environmentally friendly continuous process;
- Blending of devulcanized rubber and commercially available plastics offer a possibility to produce cost efficient materials;
- Dynamic vulcanization is known to improve many of the properties of the thermoplatic vulcanizates (TPV)

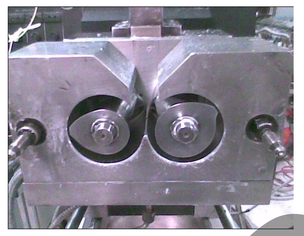
Objectives

- To prepare thermoplastic vulcanizates from devulcanized rubber;
- To understand the phenomena behind DCP/Sulphur curing;
- To test the applicability of DCP/Sulphur curing system on devulcanized EPDM

Experimental

1. Twin screw extruder and batch mixer





2. Design of Experiments and Results

Experiment No.	A	B	C	D	K	L	M	N	*C.P (3)*
Components									
DR %	80	78	78	76	40	40	40	40	60
PP %	20	20	20	20	60	58	58	56	40
DCP%	0	0	2	2	0	0	2	2	1
Sulphur%	0	2	0	2	0	2	0	2	1

- **Devulcanized Tire Tread Rubber and PP**

	A	B	C	D	K	L	M	N	CP1	CP2	CP3
TS MPa	2.52	2.9	8.4	6.9	11.2	10.3	5.5	21.6	6.06	11	8.91
S.D	.1	0.1	0.9	0.6	_	1.0	0.2	1.2	0.34	0.26	0.62
EB %	30	47.3	71.7	34.9	7.8	5.8	3.8	20.1	10.75	21.13	15.13
S.D	.1	12.7	11.2	6.9	_	1.3	0.0	7.9	3.13	0.95	3.3

- **Devulcanized EPDM Rubber and PP**

	A2	B2	C2	D2	K2	L2	M2	N 2	CP1	CP2	CP3
TS MPa	3.5	4.8	3.9	6	12	14.7	-	14.6	11	13	9
S.D	0.4	.2	0.2	0.1	1	1.1	-	1	1.4	1	0.2
EB %	24	25.3	22.75	41.7	7.2	9.7	-	10.8	8.3	9.6	7
S.D	3.5	3.3	2.8	2	1	1.5	-	2	0.4	3	1.2

Model equations

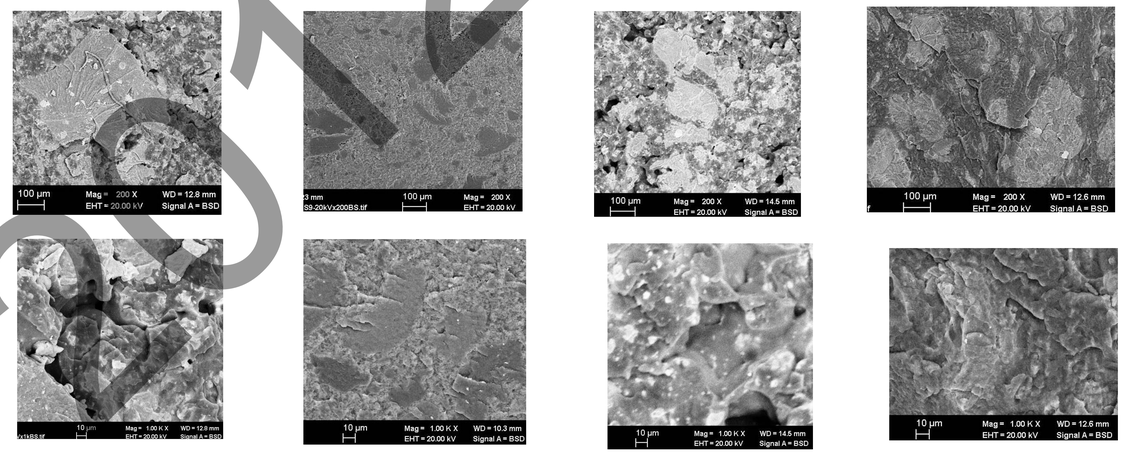
Devulcanized Tire rubber–PP blend

TS = - 0.01 (DR) + 0.2 (PP) – 277.6 (DCP) – 0.01 (S) + 3 (DR*DCP) + 3.1 (PP*DCP) – 0.01 (DR*PP*DCP) + 0.1 (PP*DCP*S)
EB = 0.4 (DR) – 0.14 (PP) – 2432.4 (DCP) + 137 (S) + 25.2 (DR*DCP) + 24.6 (PP*DCP) + 1.84 (PP*S) – 0.1 (DR* PP* DCP) + 0.5 (PP* DCP * S)

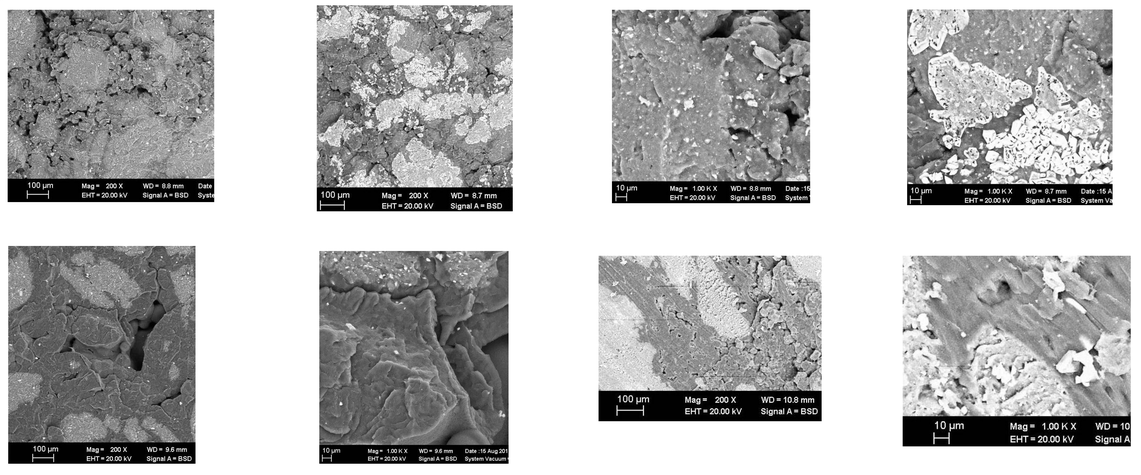
Devulcanized EPDM-PP blend

TS = -0.02(DR-E) + 0.2 (PP) -329.6(DCP) + 1 (S) + 3.4 (DR-E*DCP) + 3.2 (PP*S) + 0.02(DR-E*DCP*S) + 0.1 (PP * DCP * S)
EB= 0.5 DR-E + 0.5(PP) + 305.5 (DCP) - 3(S) - 0.02 (DR-E*PP) – 3.08 (DR-E*DCP) + 0.07(DR-E*S) – 3.2 (PP*DCP)

Morphology



SEM of samples A, C, K and N at 200x and 1000x magnification



SEM of samples A2, D2, K2 and N2 at 200x and 1000x magnification

Concluding Remarks

- Devulcanized rubber is as such not compatible with general plastics such as PP. Hence there is a need to use compatibilzers in order to prepare commercially useful TPVs.
- DCP and sulphur system seems to be good cure compatibilizer for our system of polymers.
- Use of DCP/sulphur system depends on the type of the devulcanized rubber, and their ratios have to be manipulated accordingly.