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Tensile Properties of NBR with different types of Nanofillers

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Abstract – The tensile test was carried out in a universal testing machine Instron 4202 according to ASTM D412-C. Two types of acrylonitrile–butadiene rubber (NBR) filled with 5 different types of nanofillers were used. The difference between the two rubbers was their molecular weight; the acrylonitrile content was kept constant. The measured mechanical properties were tensile strength, elastic module at 100% elongation. The NBR 3350 tensile properties values are higher than NBR 3330, showing that mechanic tensile test is effective, because the NBR 3350 Mooney viscosity [ML(1 + 4) 100℃ 48] is bigg er than NBR 3330 Mooney viscosity [ML(1 + 4) 100℃ 28].

The tensile test was carried out with a universal testing machine Instron 4202 according to ASTM D412-C. For tests was used load cell of 5 KN and extensometer. Five specimens were used and the average was calculated in each case. Tensile strength, elastic module at 100% elongation, and elongation at break readings were measured.

NBR 3330 nanocomposites showed a slight growing in some properties values. On the other hand, the use of Bentonite, that showed no significant influence in tensile strength and modulus at 100%, promoted an increase in the elongation of break value with 1 phr (463%), approximately twice the value of the pristine rubber (236%). It was impossible to run the tests in the samples with 1 and 3 phr of nanosilic and nanocalcium carbonate, because it was not possible to cut the samples in dumb-bell shape due to their high brittleness.

In the case of NBR 3350, all the samples showed increase in their properties with 3 phr nanofiller, including Bentonita that showed the higher elongation at break value (523%). The sample with 3 phr of nanosilic showed the highest increase in tensile strength and elastic module at 100%, being the highest values in comparison with the others nanofillers. This is probably due to the circular shape of the nanofiller, which enhance the dispersion in the polymer during the mixing process. However, this material showed a small value of elongation at break, typical of a more rigid material. An important aspect to be noticed was the increase in all the tensile properties values with 7 phr of Cloisite 30B. The presence of this nanofiller made a stronger nanocomposite, but the elongation at break was not decreased, like it often happens with other fillers, showing a possible exfoliation of the nanofiller in the nanocomposite [1].

Finally, the NBR 3350 tensile properties values were higher than NBR 3330, as expected due to their different Mooney viscosity and molecular weights [2]:

NBR 3350 Mooney viscosity = 48 [ML(1 + 4) 100℃]

NBR 3330 Mooney viscosity = 28 [ML(1 + 4) 100℃].

Table 1: Tensile properties of NBR 3330 (A) and 3350 (B).

		NBR 3330 (A)									NBR 3350 (B)								
Nanofiller	Amount (phr)	Tensile strength (Mpa)	Standard deviation	Rate (%)	Elongation at break (%)	Standard deviation	Rate (%)	Elastic module at 100% (Mpa)	Standard deviation	Rate (%)	Tensile strength (Mpa)	Standard deviation	Rate (%)	Elongation at break (%)	Standard deviation	Rate (%)	Elastic module at 100% (Mpa)	Standard deviation	Rate (%)
		2,75	0,41		236	54		1,44	0,08		3,18	0,57		312	39		1,39	0,25	
Silic	1										2,97	0,33	93,4	371	62	118,9	1,37	0,08	98,56
	3										4,06	0,32	127,7	308	81	98,72	1,71	0,23	123
	5	3,07	0,65	111,6	349	49	147,9	1,27	0,03	88,19	3,87	0,34	121,7	321	49	102,9	1,71	0,12	123
	7	2,25	0,23	81,82	301	31	127,5	1,24	0,05	86,11	3,08	0,23	96,86	418	47	134	1,34	0,08	96,4
Calcium Carbonate	1										2,71	0,1	85,22	359	38	115,1	1,16	0,04	83,45
	3										2,19	0,21	68,87	369	13	118,3	1,1	0,02	79,14
	5	2,83	0,71	102,9	342	67	144,9	1,28	0,07	88,89	3,39	0,19	106,6	269	41	86,22	1,56	0,15	112,2
	7	2,88	0,46	104,7	398	75	168,6	1,29	0,1	89,58	2,88	0,33	90,57	340	56	109	1,31	0,16	94,24
Bentonita	1	2,85	0,3	103,6	463	93	196,2	1,16	0,04	80,56	2,79	0,16	87,74	314	38	100,6	1,3	0,11	93,53
	3	2,66	0,21	96,73	436	65	184,8	1,13	0,02	78,47	3,05	0,49	95,91	523	37	167,6	1,14	0,07	82,01
	5	2,75	0,09	100	390	45	165,3	1,06	0,1	73,61	3,48	0,48	109,4	397	58	127,2	1,37	0,17	98,56
	7	2,77	0,29	100,7	475	69	201,3	1,14	0,03	79,17	2,97	0,33	93,4	380	38	121,8	1,19	0,09	85,61
Cloisite 30B	1	2,73	0,38	99,27	257	50	108,9	1,45	0,17	100,7	2,84	0,37	89,31	273	37	87,5	1,38	0,13	99,28
	3	2,86	0,41	104	377	51	159,8	1,28	0,08	88,89	3,32	0,78	104,4	251	34	80,45	1,72	0,24	123,7
	5	3,53	0,22	128,4	289	30	122,5	1,77	0,19	122,9	2,68	0,22	84,28	297	61	95,19	1,47	0,09	105,8
	7	3,04	0,63	110,6	336	67	142,4	1,49	0,07	103,5	3,76	0,28	118,2	437	42	140,1	1,7	0,1	122,3
Sodic Montmorilonite	1	2,81	0,24	102,2	344	44	145,8	1,16	0,06	80,56	2,58	0,21	81,13	309	35	99,04	1,17	0,05	84,17
	3	2,53	0,08	92	358	11	151,7	1,13	0,01	78,47	3,28	0,31	103,1	353	11	113,1	1,28	0,08	92,09
	5	2,99	0,37	108,7	436	61	184,8	1,18	0,08	81,94	2,67	0,2	83,96	356	31	114,1	1,27	0,04	91,37
	7	2,98	0,43	108,4	405	32	171,6	1,18	0,05	81,94	3	0,29	94,34	374	40	119,9	1,31	0,05	94,24

[1] Arroyo, M., López-Manchado, M.A., Herrero, B., 2003. Organo-montmorillonite as substitute of carbon black in natural rubber compounds. Polymer 44 (8), 2447–2453.

[2] http://www.altrubber.com/nbr.html, 01/05/2009.