



Cross Linkage Potentiation of Nitrile Rubber by using a recently developed additive

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Abstract

Nitrile rubber is known for its high tensile strength. Several studies have focused on improving the tensile strength of nitrile rubber by incorporating different materials. However further research on the economical enhancement of tensile strength of rubber is a dynamic need. We have developed chemical additive and admixture with the trialed rubber mixed with its recipe, and were routinely processed. We recorded the produced rubber acquired 43% enhanced tensile strength compared to control sample. This could be attributed to enhanced cross linkage. This technology is easy to use, highly economical, resource savings and has no adverse effect.

Keywords

Nitrile rubber, additive, tensile strength, enhancement, economical, resource savings

Introduction

Nitrile rubber is a type of rubber that contains nitrile groups. It has several advantages in the rubber industry. It offers excellent chemical resistance and mechanical performance, making it a preferred choice for automotive applications such as hoses, seals, and gaskets (Utrera-Barrios et al., 2020). It can be used as a sealing material and damping gasket due to its excellent waterproof performance, sound insulation effect, and buffer performance (Xia, 2020). Nitrile rubber is also used in flame-retardant applications, such as in high-speed rails, where it provides excellent flame retardancy and mechanical properties (Lyu et al., 2019). Additionally, nitrile rubber is used in composite materials, where it can be combined with fly ash and tannic acid to create a material with excellent mechanical properties (Yang et al., 2017). Nitrile rubber is also used in elastic connecting devices for escape facility tunnels, where it provides high impact resistance, rebound resilience, and anti-aging performance (Jin et al., 2017). Furthermore, nitrile rubber can be blended with chlorinated polyvinyl chloride rubber to create a material with better flame retardancy, chemical resistance, and ozone resistance, making it suitable for automobile parts with high flame retardancy requirements (Li et al., 2018).

Demand for durable and good quality rubber material is always on growth peak. Increasing cross-linking in nitrile rubber has several effects viz., improved mechanical properties, resistance to compression and aging, excellent tensile stress and better abrasion performance (Zhi et al., 2014; Tomonori et al., 2015; Sugavara et al., 2019;

Koji et al., 2021). Increasing cross-linkage in nitrile rubber can be achieved by incorporating carboxyl group-containing monomers and also the use of a polyamine-based crosslinking agent further enhances the cross-linking process (**Mosaki et al., 2017; Fukumine, 2019, Fukumine, 2021**). Also several studies has shown that irradiation increased the crosslinking in nitrile rubber (**Michael et al., 2007; Vijayabaskar et al., 2008; Katarzyna et al., 2015; Inna et al., 2021**). Recently we have developed an inorganic additive, when used in the rubber processing resulted in further tensile strength enhancement.

Material

MIRGAsalt MIRGAsalt composition involves sodium carbonate monohydrate 35%, sodium carbonate anhydrous 30%, potassium nitrate 20% and sodium chloride 15% having molar mass 118.44 gm/mole. The salt exerts potentiation effect through electrostatic interaction, pH buffering and catalytic action.

The inorganic compounds used are a perspective for biomedical applications (**Tishkevichet al., 2019; Dukenbayevet al., 2019**). It is also a new synthesis method for preparation of functional material (**Kozlovskiyet al., 2021; El-Shateret al., 2022**). It is well known that the combination of different compounds, which have excellent electronic properties, leads to new composite materials, which have earned great technological interest in recent years(**Kozlovskiy and Zdorovets, 2021; Almessiereet al., 2022**).

Marketed butryl rubber and it's recipe additives used in the trial.

Method

Control sample was prepared in the nitrile polymer as table 1 and numbered as 1. Trial samples were prepared same method as control sample and numbered 2,3,4,5,6, 7, 8. MIRGAsalt at the rate (w/w) 0.25%, 0.5%, 0.75% 1%, 1.25%, 1.5 %, 1.75% (7 concentrations) were added corresponding to the number 2-8 (7 samples).

Table 1: Experimental recipe

S.no	Ingredients	Property	Phr
1	Nitrile rubber	Elastomer	100
2	Sulphur	Vulcanization agent	1.5
3	Zinc oxide	Activator	5
4	Stearic acid	Activator	1.5
5	Aluminium silicate	Filler	30
6	HS	Antioxidant	1
7	HAFCAR	Black filler	40
8	Di octylphthalate	Plasticizer	10
9	Precipitated silica	Filler	30
10	Zinc stearate	Processing aid	3
11	TMT	Accelerator	0.5
12	MBTS	Accelerator	1.5
13	Parafin wax	Anti oxidant	1.0

Individually, the samples were weighed followed by mixing, test slab moulding and subjected to cold mastication. Later tested for hardening, tensile strength, ultimate elongation and compared. The experiments were repeated six times.

Result and Discussion

Table 2: Mechanical properties trial results comparison

Sample number	SHORE'A'	TS (kg/cm ²)	EB%
1 (control)	77	128	320
2 (trials)	75	154	399
3	75	139	384
4	74	183	338
5	74	137	361
6	77	148	339
7	79	151	278
8	80	131	290

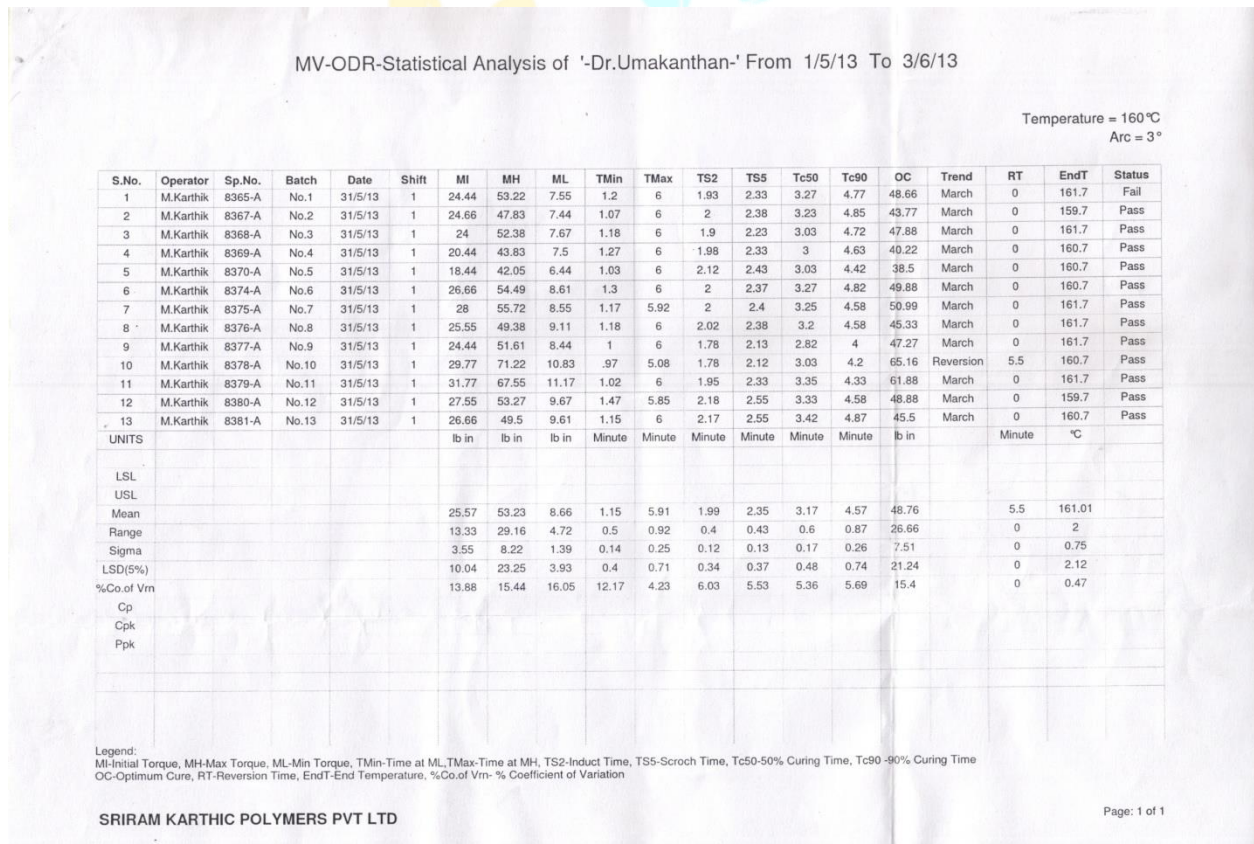


Fig 1: MV- ODR- Statistical Analysis

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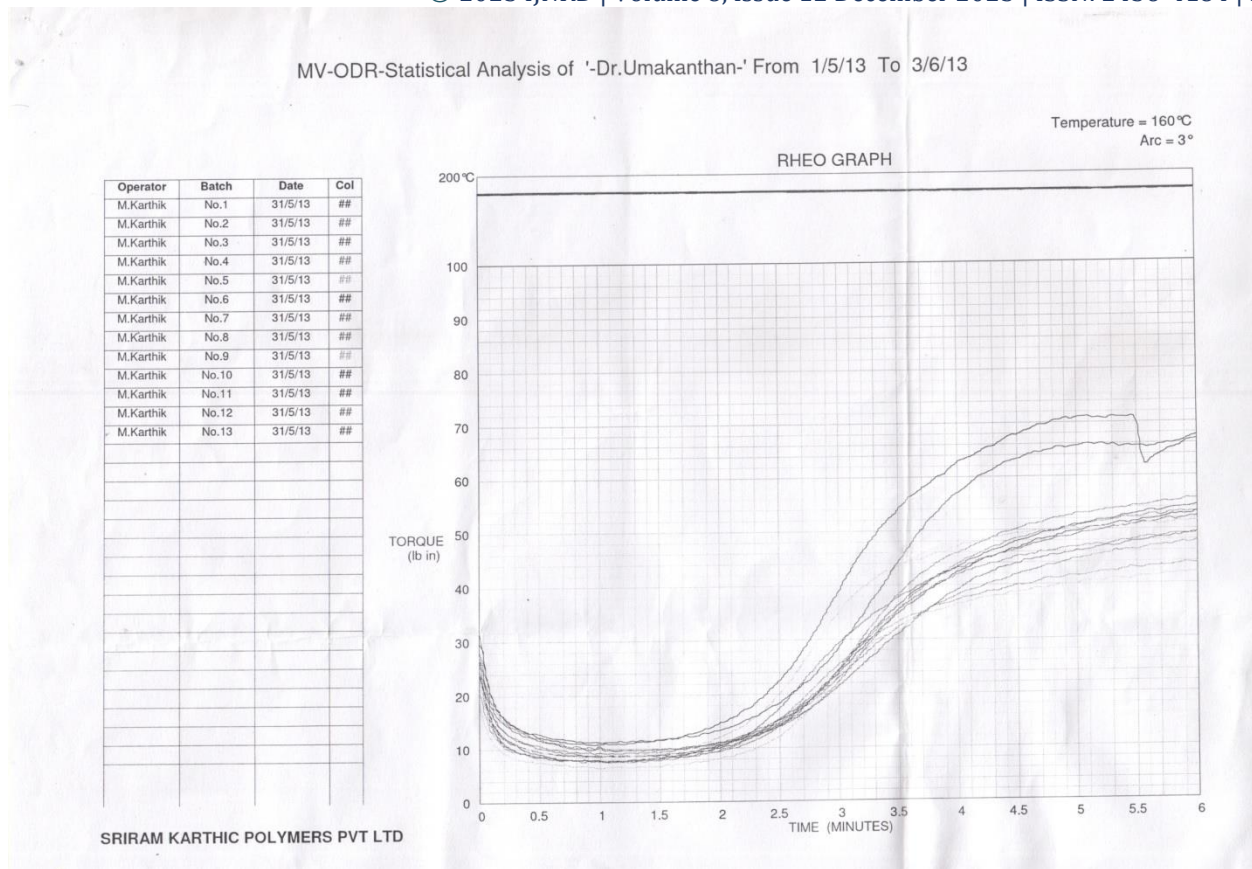


Fig 2: Rheo Graph

The results indicated that, the addition of had potentiated the physical property of the rubber compound in tensile strength (43%), ultimate elongation at break and hardness due to better cross linkage (sample 5).

Comparison with available technologies

Nitrile rubber is known for its high tensile strength. Several studies have focused on improving the tensile strength of nitrile rubber by incorporating different materials. **Shen, 2013**, developed a rubber sealing element with high tensile strength using butyronitrile rubber and various additives. **Zhao et al., 2013**, investigated the effect of carboxylic nitrile-butadiene nano-rubber particles on the tensile strength of epoxy resins and found that the addition of 5 phr of NR resulted in enhanced tensile strength. **Li et al., 2013**, developed a nitrile rubber with high acrylonitrile content, which exhibited a tensile strength of no lower than 27.5 MPa. **Erfan et al., 2017**, found that the addition of nanocellulose significantly increased the tensile strength of nitrile butadiene rubber composites. **Qi, 2017**, developed a high tensile strength rubber material by combining hydrogenated nitrile rubber, epichlorohydrin rubber, and ethylene propylene diene monomer with various additives. Introducing carboxyl group-containing monomers (**Fukumine, 2021**) and reversible strong hydrogen bonding (**Wenyan et al., 2021**) have significantly increases both the toughness and tensile strength of the elastomer.

Future benefits

1. Resource saving.

Conclusion

Recently developed inorganic chemical additive has improved the cross linking during moulding and reflected in the physical property improvement. This trial has every chance and may pave way for further enhancement of mechanical properties of rubber and polymers.

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Author contribution

Umakanthan: Conceptualization, Methodology, Supervision, Validation.

MadhuMathi: Data curation, Investigation, Visualization, Writing - Original draft preparation.

Umadevi: Project administration, Resources

Umakanthan, MadhuMathi: Writing- Reviewing and Editing.

Competing interest

In accordance with the journal's policy and our ethical obligation as researchers, we submit that the authors Dr. Umakanthan and Dr. MadhuMathi are the inventors and patentee of Indian patent for MIRGA (*granted-patent no.: 401387*) which is a major material employed in this study.

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