

**THE EFFECT OF INCORPORATION SEQUENCE OF
CURATIVE INGREDIENTS ON CURE
CHARACTERISTICS OF SOLID TIRE MIDDLE
COMPOUNDS AND PROPERTIES OF RESULTANT
VULCANIZATES**

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Degree of Master of Science

Department of Chemical and Process Engineering

University of Moratuwa

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Thesis submitted in partial fulfillment of the requirements for the degree Master of
Science in Polymer Technology

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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The above candidate has carried out research for the Master's thesis dissertation under my supervision

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ACKNOWLEDGMENTS

First, I would like to express my profound gratitude to my supervisor Dr. Susantha Siriwardhana (Deputy Director - Research (Technology), Rubber Research Institute of Sri Lanka) who gave me enormous guidance since the beginning of this research. His support and advice on technical aspects led me to complete this research with a scientific approach.

I would also like to extend my profound appreciation to Dr. (Mrs). Shantha Egodage (Senior Lecturer, Department of Chemical and Process Engineering, University of Moratuwa, Sri Lanka) because as a Co-supervisor her extended support & guidance throughout the thesis preparation and it was another pillar of the success of this research.

I wish to show my gratitude to Mr. Sarath Nishshanka who provide me the approval of laboratory facilities and the guidance of technical aspects during the research. Also, I would like to thank all staff members of Camso Loadstar Research & Development Center for providing test and laboratory facilities.

Further, my special thanks go to Prof. Jagath Premachandra who was a course co-ordinator of Master of Science in Polymer Technology Degree, because of his encouragement was streamline me to complete the research successfully.

Finally, I would like to thank family members and friends for the support, devotion, and understanding throughout the research period.

ABSTRACT

The purpose of this research is to study the effect of modification of incorporation sequence of accelerator and activators on cure characteristics, physical properties, mechanical properties and dynamic properties of solid tire middle compound.

Accelerator-activator masterbatch (MB) was prepared by mixing activators & accelerator in a rubber phase. A series of masterbatches were prepared using different concentrations and maturation periods of accelerator-activator combination and pre-vulcanization inhibitor. They were subsequently used in 1st stage compound mixing of a solid tire middle compound. Cure characteristics and selected properties of these masterbatches incorporated solid tire middle compounds were studied. Economics analysis of the best system among the candidate systems was also carried out.

It was found that the cure rate index improved by 52% with the accelerator-activator MB compared to the conventional method of curatives usage when 58.5 pphr accelerator-activator MB is used. No significant effect of the maturation time of MB on the cure characteristics and other properties was found. With the incorporation of activators and accelerators in the MB form, scorch time of the compound showed a slight drop which was overcome by the addition of 0.3 pphr pre-vulcanization inhibitors at the 2nd stage mixing stage.

Mechanical properties, dynamic properties, and visco-elastic properties of vulcanizates prepared using accelerator-activator MB and conventional methods were compared. Tensile strength, elongation at the break, blow-out time and storage modulus showed an improvement when MB incorporated vulcanizate with a slight reduction in 300% modulus, heat build-up, crosslink density, and loss modulus.

It was found that cure rate index improvement achieved associated with the reduction of curing cycle and energy consumption by around 10% and 12% respectively while maintaining other properties studied within the standard range of the conventionally prepared ones.

Key Words: Vulcanization, Accelerator, Activator, Masterbatch, Cure rate index, Optimum cure time, curing cycle time, Solid tire middle compound

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LIST OF ABBREVIATIONS

Abbreviation	Description
6PPD	N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine
AAMB	Accelerator Activator Masterbatch
ALK	Alkanolamide
ASTM	American Society for Testing & Materials
BR	Butadiene Rubber
CB	Carbon black
COM	Cost Of Manufacturing
CRI	Cure Rate Index
CTP	N-(cyclohexyl-thio)phthalimide
CV system	Conventional curing system
DBP	Dibutyl Phthalate
DMA	Dynamic Mechanical Analyzer
DTB	1-phenyl- 2,4-dithiobiuret
EAB	Elongation at Break
EPDM	Ethylene Propylene Diene Monomer
Et al	And Others
EV system	Efficient curing system
FEA	Finite Element Analysis
FF	Fast-extruding Furnace
GDP	Gross Domestic Product
GPF	General Purpose Furnace
MB	Master Batch

MDR	Moving Die Rheometer
M_H	Maximum Torque
M_L	Minimum Torque
NR	Natural Rubber
ODR	Oscillating Disk Rheometer
PPHR	Parts Per Hundrands of Rubber
PRL	Plastic Retention Index
PVC	Poly Vinyle Chloride
RPA	Rubber Processing Analyzer
RSS	Ribbed Smoke Sheet
SBR	Styrene Butadiene Rubber
SG	Specific Gravity
SRF	Semi Reinforcing Furnace
t_{90}	Optimum Cure Time
TBBS	N-Tert-Butyl-2-Benzothiazole Sulfenamides
TMQ	Polymerized 2,2,4-Trimethyl-1,2-dihydroquinoline
TMTD	Tetramethylthiuram Disulfide
TMTM	Tetramethylthiuram Monosulfide
t_{s2}	Scorch Time
TSR	Technically Specified Rubber
ZnO	Zinc Oxide

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