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Preparation, microstructure, and microstructure-properties relationship of thermoplastic vulcanizates (TPVs): A review

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ABSTRACT

It is common practice to blend polymers to obtain high-performance polymer materials for new applications. Thermoplastic vulcanizates (TPVs), consisting of a high content of crosslinked rubber as a dispersed phase and a low content of thermoplastic as a continuous phase, are usually prepared by pre-blending rubber and plastic phases followed by dynamic vulcanization. They are a special class of high performance thermoplastic elastomers (TPEs) as they combine both the excellent elasticity and mechanical properties of crosslinked rubbers and good processability and recyclability of thermoplastics. As such, in the recent decades they have attracted much attention and have become the fastest growing elastomers to replace unrecyclable thermoset rubbers. This review focuses on recent progresses in TPVs, and more specifically on the following issues: (1) preparation methods of TPVs, (2) mechanisms of formation of the microstructure of TPVs; (3) relationships between the microstructure and properties, (4) review of various types of TPVs, including general TPVs, special TPVs, bio-based TPVs, and TPVs-based nanocomposites, (5) future challenges on TPVs.

Contents

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Nomenclature

3D	Three dimensional
ABS	Acrylonitrile-butadiene-styrene
ACM	Acrylic rubber
AD	2,5-dimethyl-2,5-di(*tert*-butylperoxy)hexane, a free radical initiator
AEM	Acrylic ethylene elastomer
AFM	Atomic force microscopy
ASTM	American society of testing materials
ATBN	Amine-terminated butadiene-acrylonitrile copolymer
ATBN	Amine-terminated butadiene-acrylonitrile copolymer
BA	Butyl acrylate
BIIR	Brominated isobutylene-isoprene rubber
BMI	*N,N*'-m-phenylene-bismaleimide
BPE	Biobased polyester elastomer
BT	Barium titanate
$CaCO_3$	Calcium carbonate
CB	Carbon black
CD	Crosslinking degree
CHP	Cumyl hydroperoxide, a crosslinker
CIIR	Chlorinated isoprene-isobutylene rubber
CNF	Carbon nanofiber
CNTs	Carbon nanotubes
COPA	Copolyamides
COPE	Copolyesters
CPE	Chlorinated polyethylene
CS	Compression set
DCP	Dicumyl peroxide
DMTA	Dynamic mechanical thermal analysis
DOP	Dioctyl phthalate
DPIM	Dynamic packing injection molding
DSC	Differential scanning calorimetry
DTBPIB	Di(*tert*-butylperoxyisopropyl) benzene
DV	Dynamic vulcanization
EB	Elongation at break
EIReP	Electron induced reactive processing
ENB-EPDM	Ethylidene norbornene (ENB) containing ethylene propylene diene monomer rubber
ENR	Epoxidized natural rubber
EOC	Ethylene octene copolymer
EPDM	Ethylene-propylene-diene monomer rubber
EPDM-g-MAH	Ethylene-propylene-diene monomer rubber grafted maleic anhydride
EPM	Ethylene-propylene monomer rubber
EVA	Ethylene-co-vinyl acetate copolymer (VA content <50%)
EVM	Ethylene-vinyl acetate rubber (the content of vinyl acetate (VA) is 50%)
EVM-g-MAH	Maleic anhydride-grafted ethylene-vinyl acetate rubber
FEA	Finite element analysis
FIB	Focused ion beam