EFFECTS OF METAL OXIDES NANOPARTICLE FILLERS ON ETHYLENE-PROPYLENE-DIENE RUBBER (EPDM) PROPERTIES

By
Eng. Yasser Mohamed Tufik Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment
of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
CHEMICAL ENGINEERING

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Title of Thesis:

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Key Words:

Metal oxides; Nanoparticle; Fillers; EPDM

Summary:

The present work is concerned with improving the mechanical properties and thermal stability of Ethylene propylene diene monomer EPDM by using metal oxide nanofillers. Metal oxide nanoparticles (nMO) such as (nCuO), (nFe_2O_3), (nZnO) and (nNiO) (size 50–100 nm) are synthesized by Sol-Gel technique and characterized. The effect of incorporating nMO, as nanofillers on the curing vulcanization behavior, morphology, mechanical properties, swelling and thermal properties of ethylene-propylene-di ene EPDM elastomer compound is studied. The obtained results of the new composite were compared with ethylene-propylene-diene (EPDM) elastomer filled by conventional metal oxide (cMO) such as (cFe_2O_3, cNiO, cZnO, cCuO).

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NOMENCLATURE

A	frequency factor, (min^{-1})
CRI	Cure rate index
CuO	Copper oxide
cMO	Conventional metal oxide
DTG	Differential thermogravimetry
D	Diffusion coefficient
EG	Ethylene glycol
EPDM	Ethylene propylene diene monomer
E	Activation energy [kJ/mol]
E_X	The activation parameters of diffusion or permeation, either E_D or E_P.
E_D	The activation parameters of diffusion
E_P	The activation parameters of permeation
E_a	Apparent activation energy at α [kJ/mol]
Fe_2O_3	Iron Oxide
f(x)	The function of the conversion
h	The rubber thickness, m
k	A constant depends on the polymer morphology and the polymer-solvent interaction
k	Rate constant (min)
M	Molecular weight, g/mole
MO	Metal oxide
MEG	Mono-ethylene glycol
M_H	Maximum torque,
M_L	Minimum torque,
M_∞	The mass of toluene sorbed at equilibrium
M_0	The initial mass of EPDM/metal oxide
MWLR	Maximum weight loss rate corresponding to DTG peak maxima, (% min^{-1})
MDR	Monsanto Moving Die Rheometer
NiO	Nikel Oxide
nMO	Metal oxide nanoparticle
n	Reaction order [–]
n	Value determines mode of transport of toluene through the EPDM
Phr:	Part per hundred parts of rubber.
P	Permeability coefficient
PEG	Polyethylene glycol

Q_t	Molar percentage uptake at time t
Q_α	The equilibrium absorption or swelling
R	Gas constant (8.3134 J K^{-1} mol^{-1}) or 82.0567 cm^3atm/deg.mol
R^2	Linear regression
S	The sorption coefficient
t	Time, (min)
t_{90}	Cure time
t_2	Scorch time
$\sqrt{t}$	Square root of time
T	Tempreatur
T_m	Maximum temperature peak, Tempreature at maximum convertion [^{o}C]
T_i	Initial degradation temperature, (°C)
TGA	Thermogravimetry analysis
w_S	Weight of swollen rubber [g]
w_t	Weight [g]
w_0	Initial Weight [g]
w_f	Final Weight [g]
XRD	X-ray difraction
x	Amount adsorbed, mole
X	A constant representing either D or P,
X_0	A constant representing either D_o or P_o,
x	Convertion (-)
ZnO	Zinc Oxide
Z	Denotes moles of solvent sorbed at equilibrium swelling

Greek Symbols

ΔH_S	The heat of sorption
θ	The slope of the initial linear portion of the plot of Q_t against $\sqrt{t}$,
β	Heating rate, (°C min^{-1})