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Silicone containing copolymers: Synthesis, properties and applications

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ABSTRACT

A comprehensive survey of the recent developments on the synthesis, properties and applications of silicone containing copolymers is provided. Influence of (—R_2Si—O—) backbone composition on the physicochemical properties of silicone copolymers, such as thermal transitions, solubility parameter and surface tension is discussed. Preparation and properties of well-defined α,ω-reactive organofunctionally terminated (telechelic) silicone oligomers and their utilization in the preparation of a wide range of block and segmented copolymers through step-growth, anionic, ring-opening and living free-radical polymerization techniques are provided. Use of silicone oligomers in the modification of polymeric network structures is also discussed. Special emphasis is given to the discussion of the effect of silicone oligomer and organic segment structure and molecular weight on the morphology and surface and bulk properties of the resultant silicone containing copolymers and networks.

Contents

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Nomenclature

AFM	atomic force microscopy
ATR-FTIR	attenuated total reflectance Fourier transform infrared spectroscopy
ATRP	atom transfer radical polymerization
BD	1,4-butanediol
D_3	hexamethylcyclotrisiloxane
D_4	octamethylcyclotetrasiloxane
DLS	dynamic light scattering
DMA	dynamic mechanical analysis or dynamic mechanical analyzer
DMAC	dimethylacetamide
DMF	dimethylformamide
DMT	dimethylterephthalate
FTIR	Fourier transform infrared spectroscopy
HDPE	high density polyethylene
HMDI	bis(4-isocyanatocyclohexyl)methane
HS	hard segment
LC	liquid crystalline
MDI	bis(4-isocyanatophenyl)methane
$\langle M_n \rangle$	number average molecular weight
MWD	molecular weight distribution
NMP	N-methyl-2-pyrolidone
NMR	nuclear magnetic resonance spectroscopy
PA6	polyamide 6 or nylon-6
PB	polybutadiene
PBLG	poly(γ-benzyl-L-glutamate)
PBT	poly(butylene terephthalate)
PC	polycarbonate
PCL	polycaprolactone
PDI	polydispersity index
PDMO	poly(decamethylene oxide)
PDMS	polydimethylsiloxane
PDPS	polydiphenylsiloxane
PE	polyethylene
PEO	poly(ethylene oxide)
PHMO	poly(hexamethylene oxide)
PI	polyisoprene
PLA	poly(D,L-lactide)
PLLA	poly(L-lactide)
PMMA	poly(methyl methacrylate)
PMPS	polymethylphenylsiloxane
PMVS	polymethylvinylsiloxane
PNBA	poly(*n*-butyl acrylate)
POX	poly(2-ethyloxazoline)
PP	polypropylene
PPO	poly(propylene oxide)
PS	polystyrene
PSF	polysulfone
PTFPMS	poly(3,3,3-trifluoropropylmethylsiloxane)
PTMO	poly(tetramethylene oxide)
ROP	ring opening polymerization
SAXS	small angle X-ray scattering
SEC	size exclusion chromatography
SEM	scanning electron microscopy
TEM	transmission electron microscopy
T_g	glass transition temperature
T_m	melting temperature
TGA	thermogravimetric analysis
THF	tetrahydrofuran
TPU	thermoplastic urethane
TPUU	thermoplastic urethaneurea
UV	ultraviolet radiation
WAXD	wide angle X-ray diffraction
WAXS	wide angle X-ray scattering
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction

1. Introduction

Polymeric materials composed of a (—Si—O—) backbone with two monovalent organic radicals attached to each silicon atom (—R_2Si—O—), as shown in Fig. 1, are generally called "silicone" polymers. The (—Si—O—) repeat unit is also called as the "siloxane" bond or linkage and therefore other terms used to describe these types of polymers also include siloxane polymers and polysiloxanes. Since the polymer backbone is "inorganic" in nature, while the substituents attached to the silicon atom are generally "organic" radicals, silicones form an important bridge between inorganic and organic polymers. Because of the dual nature of their backbones another widely used name to describe silicone polymers is polyorganosiloxanes [1–4]. In this manuscript we will use the term siloxane to describe the backbone unit and silicone to describe the polymers.

A main interest in silicone containing copolymers and silicone-modified networks is directly related to the interesting combination of properties offered by these materials, which include extremely high backbone

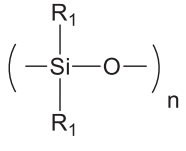

Fig. 1. General structure of silicone or siloxane polymer backbone.

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