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Polymers for enhanced oil recovery: A paradigm for structure–property relationship in aqueous solution

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ABSTRACT

Recent developments in the field of water-soluble polymers aimed at enhancing the aqueous solution viscosity are reviewed. Classic and novel associating water-soluble polymers for enhanced oil recovery (EOR) applications are discussed along with their limitations. Particular emphasis is placed on the structure–property correlations and the synthetic methods. The observed rheological properties are conceptually linked to the polymer chemical structure (1) and topology (2). In addition, the influence of external parameters, e.g. temperature, pH, salt, and surfactant, on the rheological behavior is reviewed. Progress booked in deeper understanding of the structure–property relationship is thoroughly discussed. Furthermore, a critical overview of the synthetic methods as well as of the solution properties of these polymers is provided. In this respect the influence of "internal" (i.e. chemical structure) and "external" (*vide supra*) factors on these properties provide a conceptual toolbox for the rationalization of the response of water-soluble polymers to external stimuli. In turn, such rationalization constitutes the basis for the design of new polymeric structures for EOR applications.

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Nomenclature

4-BA	4-butylaniline
AA	acrylic acid
ABS	alkylbenzenesulfonates
ACVA	4,4′-azobis-4-cyanopentanoic acid
AGE	alkylglycidyl ether
AM	acrylamide
AMM	associative macromonomer
AMPDAB	4-(2-acrylamido-2-methylpropyldimethylammonio) butanoate
AMPDAC	2-(acrylamido-2-methylpropyldimethylammonium) chloride
AMPDAE	2-(2-acrylamido-2-methylpropyldimethylammonio) ethanoate
AMPDAH	6-(2-acrylamido-2-methylpropyldimethylammonio) hexanoate
AMPDAPS	3-(2-acrylamido-2-methylpropane-dimethylammonio)-1-propanesulfonate
AMPTAC	2-(acrylamido)-2-methylpropyl]trimethylammonium chloride
APS	*N*-[(1-pyrenylsulfonamido)ethyl]acrylamide
BD	bromododecane
BPAM	*N*-(4-butyl)phenylacrylamide
CAC	critical association concentration
C_8AM	octylacrylamide
C_{10}AM	decylacrylamide
C_{12}AM	dodecylacrylamide
C_{14}AM	tetradecylacrylamide
C_{18}AM	octadecylacrylamide
C_NAM	alkylacrylamide
C_{12}Acl	dodecyl ammonium chloride
C_{16}TAAc	hexadecyltrimethyl ammonium acetate
C_{12}TABr	dodecyltrimethyl ammonium bromide
C_{12}TACl	dodecyltrimethyl ammonium chloride
C_{16}TACl	hexadecyltrimethyl ammonium bromide
CAC	critical association concentration
CDMAO	cetyldimethylamine oxide
CMC	critical micelle concentration
CS*	critical surfactant concentration
CTA	chain transfer agent
CTAB	cetyltrimethyl ammonium bromide
CTAT	cetyltrimethyl ammonium *p*-toluenesulfonate
Da	dalton
DAAM	diacetone acrylamide
DADMAC	*N*,*N*-diallyl-*N*,*N*-dimethylammonium chloride
DADPMA	[(dimethylammonioethoxy)-dicyanoethenolate]propyl-methacrylamide
DAGE	(3,3-dialkoxymethyl)propylglycidyl ether
DAMA	*N*,*N*-diallyl-*N*,*N*-methylamine chloride
DAMAPS	3-(*N*,*N*-diallyl-*N*-methylammonoi)propanesulfonate
DE*m*MA	substituted methacrylate
DiC_3AM	*N*,*N*-dipropylacrylamide
DiC_6AM	*N*,*N*-dihexylacrylamide
DiC_8AM	*N*,*N*-dioctylacrylamide
DiC_{10}AM	*N*,*N*-didecylacrylamide
DiC_{12}AM	*N*,*N*-didodecylacrylamide
DiC_{14}AM	*N*,*N*-ditetradecylacrylamide
DiC_{16}AM	*N*,*N*-dihexadecylacrylamide
DMSO	dimethylsulfoxide
DR	drag reduction
DTAB	dodecyltrimethylammonium bromide
DTAC	dodecyltrimethylammonium chloride
EΦAM	*N*-(4-ethyl-phenyl)acrylamide
EA	ethyl acrylate
EHEC	ethyl hydroxyethyl cellulose
EO	ethylene oxide
EOR	enhanced oil recovery
EP16	1,2-epoxyhexadecane
EVE	ethyl vinyl ether
FX-13	2-(*N*-ethylperfluorosulfoamido)ethyl acrylate
FX-14	2-(*N*-ethylperfluoro-octane/sulfoamido)ethyl methacrylate
HASE	hydrophobically modified alkali swellable emulsion