

Synthesis And Evaluation Of Novel Cationic Monomers Viscosifiers For Oil Well Drilling Fluids

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Abstract: Novel cationic monomers capable of forming viscoelastic fluid were prepared. The monomers were formed through the quaternization reaction of allyl halides with dimethylalkylamines, triethanolamine or N-N dimethyl aniline. The chemical structures of the prepared monomers were confirmed using FTIR and ^1H -NMR spectroscopy. The result of the spectroscopic analysis indicate that they were prepared through right method they have high purity and their surface properties were studied. The cationic monomer products were evaluated as viscosifiers and filter loss additives for water –base mud because they were capable of forming viscoelastic fluids in high brine solution. Rheological properties, gel strength, filter loss and thermal stability of the water- based mud formulated with the new cationic monomers were studied compared to the commercial viscosifier (reference sample mud). [A.M., Badwi, M. M., Dardir and H. M., SYNTHESIS and EVALUATION of NOVEL CATIONIC MONOMERS VISCOSIFIERS for OIL WELL DRILLING FLUIDS. Journal of American Science 2011;7(1):473-484]. (ISSN: 1545-1003). <http://www.americanscience.org>.

Keyword: Drilling fluids-Viscosifier-Rheological properties

Introduction:

In the field of drilling for the exploration for oil and gas, an important component is that of the formulation of drilling muds.⁽¹⁻⁵⁾ Drilling muds are the fluids which are used to maintain pressure, cool drill bits and lift cuttings from the holes and vary in composition over a wide spectrum. Generally, drilling muds are based on aqueous formation or oil-based formulations.⁽⁶⁻¹²⁾ A conventional water-based drilling mud formulation is composed basically of the following ingredients: water, clay such as bentonite, lignosulfonate, a weighting agent such as BaSO_4 (Barite) and a caustic material such as sodium hydroxide to adjust the pH of the drilling mud to a pH of about 10 to 10.5.⁽¹³⁻¹⁵⁾ This formulation with its high density due to the addition of high concentrations of insoluble solid, high density particulates (weighting agents such as Barites). However, this particulates inhibited the drilling rate and possibly damaged a variety of underground formations.⁽¹⁶⁻¹⁸⁾ This problem becomes even more acute as the drilling fines are introduced into the mud. Therefore, there has been a substantial need for a homogenous, high density drilling mud which exhibits good performance at both high temperature and high ionic strength. Previously, a very desirable change in the formulation of a drilling fluid would be by the elimination of all added particulates.⁽¹⁹⁾ One particular approach to this problem is to formulate a drilling fluid which is clear, homogenous, dense, single phase and possess the appropriate viscosity requirements. Therefore a water-based mud containing principally clay and a polymeric viscosifier in a high concentration brine (weighting agent) could meet the above-stated requirements.

Polymeric materials are generally considered useful as viscosification agents when dissolved in appropriate solvent system. The major reason for this viscosity enhancement is due to the very large dimensions of the individual polymer chain as compared to the dimension of the single solvent molecule. Any increase in the size of the polymer chain will produce corresponding enhancement in viscosity of the solution. This effect is maximized when the polymer is dissolved in a good solvent. Therefore, in general, a soluble polymer is useful for thickening solvent while a water soluble polymer is appropriate for increasing the viscosity of aqueous systems. With regard to aqueous solutions, solvent soluble nonionic polymers and high charge density sulfonated or carboxylate polyelectrolytes are quite useful in this regard and are commonly used materials. These materials become especially effective at concentration where the individual polymer chains begin to overlap.⁽²⁰⁾ To overcome the difficulties experienced in conventional polymer viscosifiers and rheological control additives in aqueous media a novel family of cationic-alkyl monomers i.e. polymerizable moieties, form a large structure in solution, and enables the efficient viscosification of aqueous fluids without the need for a moderate or high molecular weight water soluble polymer. The structure of these monomers are useful and very effective viscosifier for aqueous solution. In addition, these monomers have markedly unique and improved solution properties as compared to the conventional water soluble polymers. These monomers overcome the difficulties experienced in conventional polymer viscosifiers and rheological control additives in aqueous media. In particular, it enables the efficient viscosification of aqueous fluids

without the need for a moderate or high molecular weight water soluble polymer.

The main property of the prepared monomers are being a cationic surfactant. So, they achieve solubility and thickening efficiency which make this system very sensitive, as well as very sensitive to small changes in surfactant and polymer concentrations.⁽²¹⁻²²⁾

Experiments:

Synthesis of monomer structures:

Synthesis of quaternary ammonium compounds:

N,N dimethyl dodecylamine, triethylamine or N,N dimethyl aniline (1 mole) each was added to allyl Bromide (1 mole) in the presence of xylene as a solvent, the reaction mixture was refluxed at 50°C for 6 hours. The solution was evaporated under reduced pressure and the monomers were further purified through conventional analytical techniques.⁽²³⁾

1- Correct elemental analysis was measured in Micro Analytical Center, Cairo University.

1- FTIR spectra using ATI Mattson infinity seriesTM, Bench top 961 controlled by win first TM V2.01 soft ware. (Egyptian Petroleum Research Institute).

2- ¹H NMR was measured in DMSO-d₆ by spect varian, GEMINI 200 (1H200 MHz). (Micro Analytical center, Cairo University).

Elemental analysis, FTIR and ¹H NMR analysis confirm that the monomers are very pure and have the following molecular structure

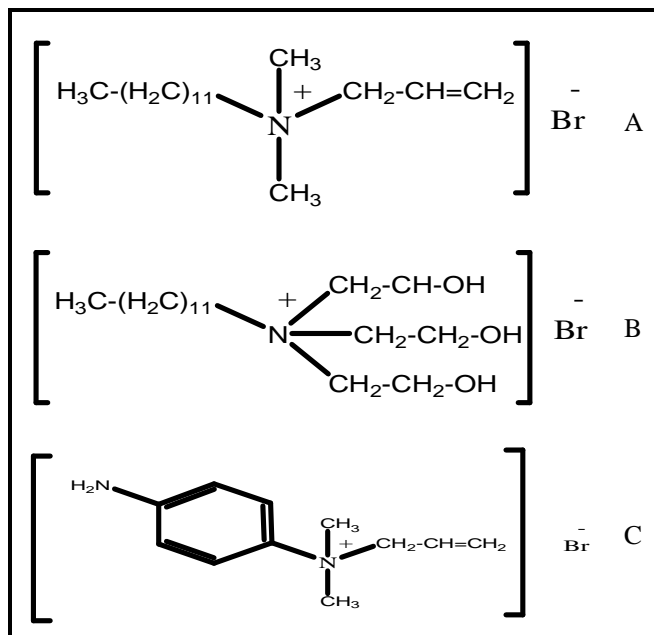


Fig (1) the chemical structures of the synthesized compounds.

Surface tension and interfacial tension:

Surface tension and interfacial tension of the prepared compounds solutions were measured using Du-Nouy tensiometer (Krass type 8451). The interfacial tension between 0.1% surfactant solution and light paraffin oil was also measured at 25°C.

The surface parameters of the synthesized compounds:

Critical micelle concentration (CMC):

The values of CMC of the prepared compounds were determined using surface tension techniques, where in this method, values of the surface tension measurements were plotted against the corresponding concentration. The interrupt change in the SC curves express on the CMC concentrations.

Effectiveness (CMC):

CMC is the difference between the surface tension of the pure water (σ_0) and the surface tension of the surfactant solution (σ) at the critical micelle concentration.

$$CMC = \sigma_0 - \sigma$$

Efficiency (PC₂₀):

Efficiency (PC₂₀) is determined by the concentration (Mol/L) of the surfactant solutions capable to suppress the surface tension by 20 dyne/cm.

Maximum surface excess r_{max} :

The values of the maximum surface excess r_{max} were calculated from surface or interfacial data by the use of Gibbs equation.

$$r_{max} = -1 / 2.303RT (\delta\gamma / \delta \log c)_T$$

Where:

r_{max} = maximum surface excess in mole/cm².

R = Universal gas constant 8.31 x 10⁷ Ergs mol⁻¹

T = absolute temperature (273.2 + °C)

$\delta\gamma$ = surface pressure in dyne/cm.

C = surfactant conc.

$(\partial\gamma / \gamma \log c)_T$ is the slope of a plot surface tension Vs. concentration curves below CMC at constant temperature.

Minimum surface area (A_{min}):

The area per molecule at interface provides information on the degree of packing and the orientation of the adsorbed surfactant molecule. The average area (in square angstrom) occupied by each molecule adsorbed on the interface is given by:

$$A_{min} = 10^{16} / \Gamma_{max} N$$

Where:

r_{max} = maximum surface excess in mole/cm²

$N = \text{Avogadro's number } 6.023 \times 10^{23}$

Tests for water – base mud:

The prepared cationic monomers A,B and C were evaluated as a viscosifier and filter loss additives for water-base mud compared to the commercial viscosities. The mud batches of local bentonite using fresh water treated by a new prepared cationic monomers A, B and C or reference viscosifier R with concentration of 0.5% for a viscosifier additive.⁽²³⁾

Mud formulation:

Formulation of the mud were as follow:

- 6% of local bentonite + 500 ml fresh water
- 1- The samples were mixed in a Hamilton mixer for 20 minutes then cured overnight.
 - 2- Each sample was stirred for 15 minutes, before the rheological and filtration properties were measured before adding viscosifier.
 - 3- 0.5% of a new viscosifiers A,B and C and commercial one were added to local bentonite mud batches.
 - 4- The samples were mixed for 20 minutes and cured overnight.
 - 5- Each sample was stirred for 15 minutes, then the rheological and filtration properties were measured.

MR: Water-base mud formulated of 6% local bentonite and (commercial emulsifier R).

MA: Water-base mud formulated of 6% local bentonite and 0.5% cationic monomer (A).

MB: Water-based mud formulated of 6% local bentonite and 0.5% cationic monomer (B).

MC: water-based mud formulated of 6% local bentonite and a cationic monomer (C).

Results and discussion:

Chemical structure:

The chemical structure of the prepared cationic monomers were confirmed by:

- 1- Correct elemental analysis.
- 2- The FTIR spectroscopy was used to identify the functional groups of the prepared cationic surfactant .The FTIR spectrum of compound (A) shows, stretching vibration of –C-H aliphatic symmetric and asymmetric at 2827.15 & 2976.18 cm^{-1} respectively, 2605.64 cm^{-1} for (N^+), (C – N) amine at 1034.58 cm^{-1} , and weak absorption band of (C=C) alkene at 1630.88 cm^{-1} , and –CH₂ bending at 1438.19 cm^{-1} . we observe disappearance of the absorption bonds of –NH at 3300 cm^{-1} .

The FTIR spectrum of compound (B) shows, (C=O) stretching at 1038.88 cm^{-1} , (C-N) amines at 1302.80 cm^{-1} , (-CH₂) bending at 1455.18 cm^{-1} , weak absorption band of (C=C) alkene at 1594.36 cm^{-1} ,

(CH₂) stretching at 2924.29 cm^{-1} and broad absorption band of (O-H) at 3300 cm^{-1} .

The FTIR spectrum of compound (C) shows, (C-H) aromatic out-of-plane bend at 690 cm^{-1} , (C-N) amine at 1120.92 cm^{-1} , medium absorption band of (C=C) aromatic at 1487.90 cm^{-1} , weak absorption band of (C=C) alkene at 1627.45 cm^{-1} , (C-H) Aromatic stretching at 3114.79 cm^{-1} and absorption band of (NH₂) stretching at 3422.04 cm^{-1} .

The ¹H NMR spectra data (ppm) of the compound (A), shows bands at 0.787 – 0.848 ppm (t, 3H, CH₃(CH₂)₁₁ –), at 1.137-1.212ppm (m, 4H, CH₃(CH₂)₁₀ –), at 2.129-2.218ppm (t, 3H, CH₃ (CH₂)₁₀ (CH₂) –), at 3.060ppm (s, 1H, H₃ C – N – CH₃), at 4.075 – 4.111ppm (d, 2H, - N – CH₂ – CH = CH₂), at 5.595 – 5.692ppm (d, 2H, CH₂ = CH –), and at 5.968 – 6.173ppm (m, 5H, CH₂ = CH – CH₂ –).

The ¹H NMR spectra data of compound (B), shows bands at 3.456 – 3.505ppm. (t, (3 H– N– (CH₂ – CH₂)₃) ,at 3.838 ppm (s, 1 H– (CH₂– OH)₃) ,at 3.635 – 3.688 ppm (t, 3 H– (H₂C–CH₂ – OH)₃) ,at 3.635 – 3.688 ppm (d, 2H = HC – CH₂ – N), at 5.559 – 5.700ppm (d, 2H – CH = CH₂), and at 5.987 – 6.156ppm (m, 5H CH₂ = CH – CH₂ – N).

The ¹H NMR spectra of comp. (C) shows bands at 3.676ppm (S, 1H, H₃C – N – CH₃), at 3.874 – 3.906ppm (d, 2H, = CH – CH₂ – N), at 4.124 – 4.162ppm (d, 2H, - CH = CH₂), at 4.669 – 4.696ppm (S, 1H, H₂N – ph – N -), at 5.446 – 5.582ppm (m, 5H, CH₂ – CH = CH₂), at 7.528 – 7.555ppm (2H, - Ph – N⁺H₂), and at 7.964 – 8.059ppm (2H, - ph – N -).

Surface active properties:

Surface and interfacial tension:

a) The surface tension:

Surface tension values were measured for aqueous solutions of the prepared cationic monomers surfactant A,B and C with different concentration at room temperature and the data are represented in surface tension conc. curves Fig. (2). It is clear that surface tension decrease by increasing concentration and also decrease in A than B than C. This is due to in compound (A) long straight chain (hydrophobic chain) which has higher repulsion forces in the water medium. Hence, the molecules will tend to adsorb at the interface with high concentration. Meanwhile, in compound (B) the shorter branched chain has lower tendency to adsorb at the interface due to the lower repulsion occurred from the aqueous phase.

The compound (C) has one benzene ring so that the hydrophobicity of the molecules decreases and

become more hydrophilic which facilitate the molecules to found in the bulk of their solutions and hence the surface tension stays at higher values.

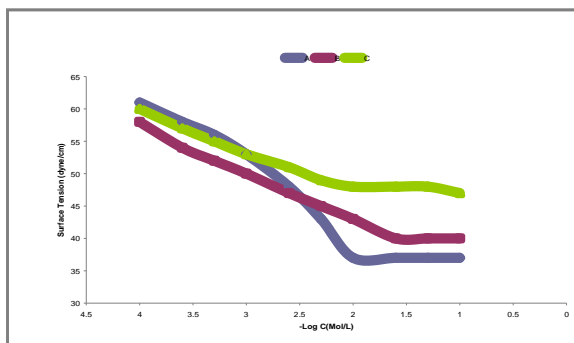


Fig.2 Variation of the surface tension with logarithm of the prepared cationic surfactants concentrations in water at 25°C

We can explain the decrease of surface tension by increasing concentration that increasing length of the hydrophobic chain is due to adsorption of surfactant molecule at the interface. We know that when materials that containing hydrophilic and hydrophobic group attached together in the same molecule dissolved in a solvent, it distort the structure of the solvent and therefore increase free energy of the system. Thus the molecules concentrate at interface in a way to minimize the free energy of the system, where the hydrophobic part oriented away from the solvent to avoid energetically unfavorable contact with aqueous media, and the hydrophilic group is directed toward the bulk. This adsorption at interface provide an expanding force acting against the normal surface tension, thus surface tension decrease.^(25,26) So by increasing the surfactant concentration, the adsorptions at interface will increase so surface tension decreases until a stable lower level is achieved. This lower level of surface tension corresponds to maximum monolayer level adsorption at air-water interface. Further increasing surfactant concentration above this maximum interfacial adsorption level lead to formation of surfactant aggregation known as micelle⁽²⁷⁾ in solution.

b) Interfacial tension:

The interfacial tension between 0.1% surfactant solution and light paraffin oil at 25°C were measured and data are shown in the table (1). From these data it is observed that by increasing hydrophobic chain length of the prepared cationic surfactants, the interfacial tension decrease.^(28, 29)

Table (1). Surface tension and interfacial tension of the synthesized cationic surfactants.

Surfactant	Surface tension, mN/m	Interfacial tension, mN/m
A	37	12
B	40	23
C	46	29

The surface parameters

The critical micelle concentration (CMC):

CMC values of the prepared cationic surfactant were determined by plotting the surface tension () of surfactant solutions versus their bulk concentration in mole/liter at room temp. the CMC values are listed in table (2) showing a decrease in the CMC with (A < B < C) due to increasing in the length of the hydrophobic chains⁽³⁰⁾.

Effectiveness (CMC):

CMC values are listed in table (2). It appears found that, effectiveness increases with the increasing of hydrophobic chain length⁽³¹⁾.

Maximum surface excess (Γ_{\max}):

The values of Γ_{\max} are represented in table (2). It is noted that increasing the hydrophobic moiety length of the prepared surfactants, Γ_{\max} shift to lower concentration and thus the surfactant molecules are directed to the interface which decrease the surface energy of their solutions^(32,33).

Minimum surface area (A_{\min}):

The minimum area per molecule at the aqueous solutions/ air interface for the prepared surfactants is listed in table (2). It is clear that A_{\min} increase with increasing length of hydrophobic moiety due to decreasing Γ_{\max} thus the distance between molecules are increased and correspondingly A_{\min} increases⁽³⁴⁾.

Efficiency (PC 20):

Efficiency values of the prepared cationic surfactants are given in the table (2). From these data it is observed that increasing the alkyl chain length, the efficiency decrease. This is due to the fact that the efficiency of adsorption at interfaces increase linearly with an increase in the carbon atoms in hydrophobic group as illustrated in discussion surface tension⁽²⁵⁻²⁸⁾.

Table (2). Surface properties of the synthesized cationic surfactants at 25°C

Surfactant	CMC	CMC _s mN/m	Pc ₂₀	$\frac{\max}{X10^{-100}}$ $\frac{mol.cm}{-2}$	A _{min} nm
A	0.005	35	0.00098	1.00295	1.6554
B	0.02	32	0.0003	1.13106	1.467
C	0.07	26	0.00025	2.20207	0.753

Thermodynamic parameters:

Adsorption and micellization processes of surfactant molecules are considered as phase transformation either from singly state molecule in the solution into adsorbed molecules at the interface (adsorption) or into the well aggregated molecules in the form of micelles (micellization). The functions are calculated using Gibb's adsorption rules As follows:

For micellization

$$\Delta G_{mic} = RT \ln(CMC)$$

For adsorption

$$\Delta G_{ads} = \Delta G_{mic} - 6.023 \times 10^{-1} \times \pi_{CMC} \times A_{mic}$$

Standard free energies of micellization and adsorption for the prepared surfactants are calculated at (25°C) according to Gibb's equations of thermodynamics and their values are listed in tables (3).

Table (3). Thermodynamic parameters of the synthesized cationic surfactants at 25°C

Surfactant	G _{mic} , KJ/mol	G _{ads} , KJ/mol.
A	-26.2244	-26.234
B	-19.362	-19.393
C	-13.162	-13.202

Negative values of the standard free energies of both micellization and adsorption for the prepared surfactants indicate that the micellization and adsorption are spontaneous processes.

The spontaneously of the process is contributed to the repulsion between the different hydrophobic moieties and the polar solvent. Hence, by increasing the hydrophobic chain length (in other statement, HLB value) increases the tendency of these molecules towards adsorption increases which result in increased negativity of ΔG_{ads} values. Thus ΔG_{mic} and ΔG_{ads} become more negative with increasing chain length. (35,36)

Evaluation of the synthesized cationic monomers as a viscosifier and water-loss control agents for water-based mud: The prepared cationic surfactants A, B and C were evaluated as viscosifiers and filter loss

additives in water-base mud. The mud formulation contain local bentonite (6%) and (0.5%) of the new viscosifier compared to the mud formulation with imported viscosifier (R).

Rheological properties: At 60°F the rheological result illustrated in fig (3) shows that the apparent viscosity for water-base mud treated with cationic surfactant A,B and C were 27, 26, 24 (cp) for MA, MB and Mc, respectively and the apparent viscosity of the reference sample MR is 25 (cp). The plastic viscosity changed from 19(cp) to 17 (cp) for MA, MB and Mc muds compared to the MR which was 16(cp).

The yield point for MA, MB and MC were (16, 18, 12 lb/100ft²), respectively while for MR was (16 lb/100ft²).

From the above result we can conclude that water-base muds MA and MB exhibit rheological properties better than MR while MC mud has rheological properties less than MR.

Gel strength: fig (4) illustrates the result of the gel strength of water-base muds MA, MB and MC compared to the MR at 60°F.

G 10sec: the gel strength were (13, 15, 10 lb/100ft²) for MA, MB and MC, respectively while for MR was (13 lb/100ft²) which is compatible with gel strength of MA.

G 10mints: the gel strength were (16 and 17 lb/100ft²) for MA and MB which were more than (16 lb/100ft²) for MR. MC exhibited a gel strength less than MR (11 lb/100ft²).

Thixotropy: for MA (3 lb/100ft²) was more than that of MR (2 lb/100ft²). For MB (2 lb/100ft²) and MC (1 lb/100ft²) were less than MR. from the above result we can conclude that all the muds were stable and can keep their rheological properties for a period of time during the drilling operation without change.

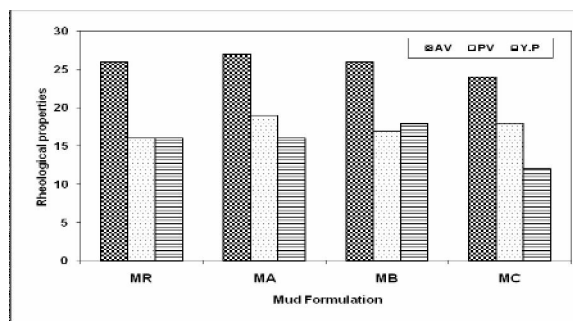


Fig. (3): Rheological properties of water-Base muds formulated with newly prepared viscosifiers compared to the reference sample mud

Effect of temperature on rheological properties of water – base mud:

In our study, the rheological properties changes with increasing temperature ranging between

60°F and 200°F. For local bentonite treated with imported viscosifier (MR): from the data represented in fig (5), it is show that the apparent viscosity decrease from 25(cp) to 14(cp), plastic viscosity decreases from 16(CP) to 10(CP) and the yield point changes from (16 lb/100ft²) to (9 lb/100ft²).

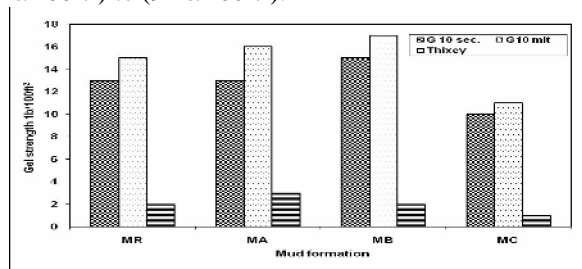


Fig. (4): Gel strength of water-Base mud formulated with newly prepared viscosifiers compared to the reference sample mud

Local bentonite treated by new viscosifiers:

MA: The apparent viscosity decreased from 27(CP) to 16(CP), the plastic viscosity decreased from 19(CP) to 12(CP) and the yield point changed from (16 lb/100ft²) to (10 lb/100ft²).

MB: The apparent viscosity changed from 26(CP) to 14(CP), the plastic viscosity changed from 16(CP) to 10(CP) and yield point decreased from (18 lb/100ft²) to (8 lb/100ft²).

MC: The apparent viscosity changed from 24(CP) to 12(CP), the plastic viscosity decreased from 18(CP) to 11(CP), yield point changed from (12 lb/100ft²) to (5 lb/100ft²).

Results of the Rheology-temperature relations indicate that the new additives A and B satisfy the minimum requirements for API specification while C has less results compared to imported viscosifier R.

Effect of temperature on gel strength.

Local bentonite with imported viscosifier: fig. (6) reveals that the gel strength decreases from (13 lb/100ft²) after 10 second to (8 lb/100ft²) as the temperature raised for 60°F to 200°F. Also it decreased for (15 lb/100ft²) to (8 lb/100ft²) after 10 mints.

Local bentonite treated by new viscosifiers (as the temperature raised from 60°F to 200°F).

MA: The gel strength after 10 sec. decreased from (13 lb/100ft²) to (8 lb/100ft²) and after 10 mints. decreased from (13 lb/100ft²) to (7 lb/100ft²).

MB: The gel strength decreased from (16 lb/100ft²) to (8 lb/100ft²) for G10 sec. and it decreased from (16 lb/100ft²) to (7 lb/100ft²) for G10 mint.

MC: The gel strength changed from (10 lb/100ft²) to (4 lb/100ft²) after 10 sec and it changed from (10 lb/100ft²) after 10 min.

The results showed that the imported viscosifier R and new prepared viscosifiers A and B are

compatible with the requirements of field mud additives but the new prepared viscosifier C has less compatibility.

Effect of temperature on shear rate and shear stress:

The shear stress value decreases as the shear rate decreases at the same temperature and fig. (7) reveals that:

At 60°F, the shear stress value decreased from (55 lb/100ft²) to (12 lb/100ft²) for MA. From (52 lb/100ft²) to (15 lb/100ft²) for (MB) and from (49 lb/100ft²) to (10 lb/100ft²) for (MC) whereas it decreased from (46 lb/100ft²) to (13 lb/100ft²) for reference (MR).

At 120°F, the values decreased from (45 lb/100ft²) to (11 lb/100ft²) for MA. From (43 lb/100ft²) to (11 lb/100ft²) for MB and from (40 lb/100ft²) to (9 lb/100ft²) for MC whereas it decreased from (39 lb/100ft²) to (9 lb/100ft²) for MR.

At 180°F, the values decreased from (36 lb/100ft²) to (8 lb/100ft²) for (MA), from (30 lb/100ft²) to (8 lb/100ft²) for (MB) and from (30 lb/100ft²) to (8 lb/100ft²) for MC whereas the values of MR decreased from (30 lb/100ft²) to (8 lb/100ft²).

The result show that muds treated with the new viscosifiers A, B and C perform good results compared to the imported viscosifier R under varying temperature.

Effective viscosity: The effective viscosity of water-based mud MA, MB and MC that were treated with the new viscosifiers (A, B, C) decreased as the shear rate increased similar to reference mud sample (MR) that was treated with imported viscosifier R. These results are illustrated in fig. (8) where vertical lines show the rpm equivalents of shear rate in sec⁻¹. Drilling fluids are usually pseduoplastic, i-e shear thinning fluids.

Filtration: table (4) shows the filter loss at pressure (100 psi) for the water-based mud (MA, MB and MC) that were treated by the new viscosifiers A, B and C compared to the reference mud sample (MR).

Table (7): filter loss (ml) for water –base mud.

Mud	Filtrate, ml
MR	13
MA	10
MB	11
MC	12

For the new viscosifier additives mud ,the corrected filter loss were between 10 ml (MA), 11 ml (MB) and 12 ml for MC whereas for MR was 13 ml. The results of all additives satisfied the international standard and the decrease of filter loss in case of MA, MB and MC indicates the stability of additives and that they show good filter loss.

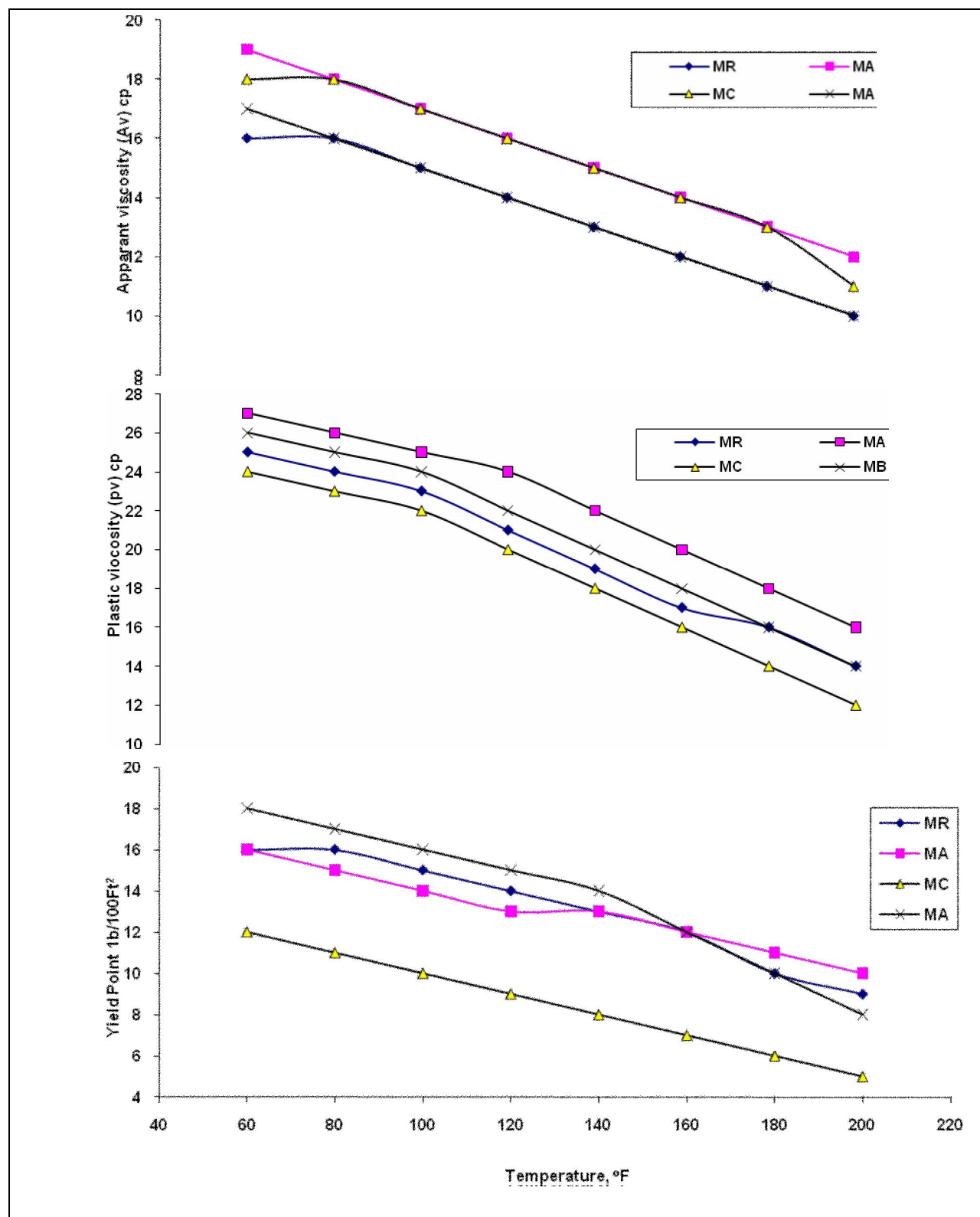


Fig. (5): -Rheological properties of water-based mud formulated with newly prepared viscosifiers with varying temperature.

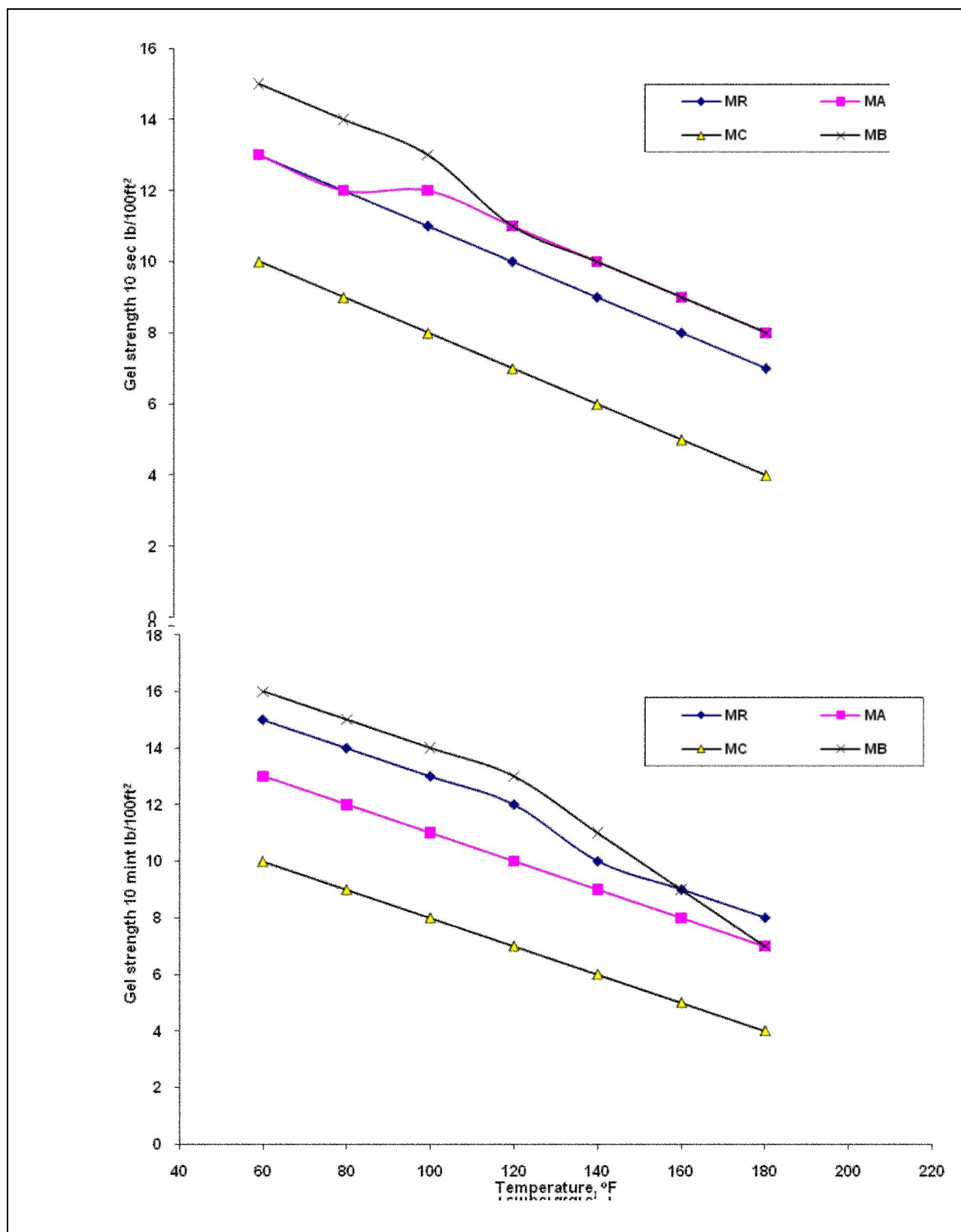


Fig. (6): Gel strength of the water-Base mud formulated with newly prepared viscosifiers A,B,C compared to the reference sample mud MR under varying Temp.

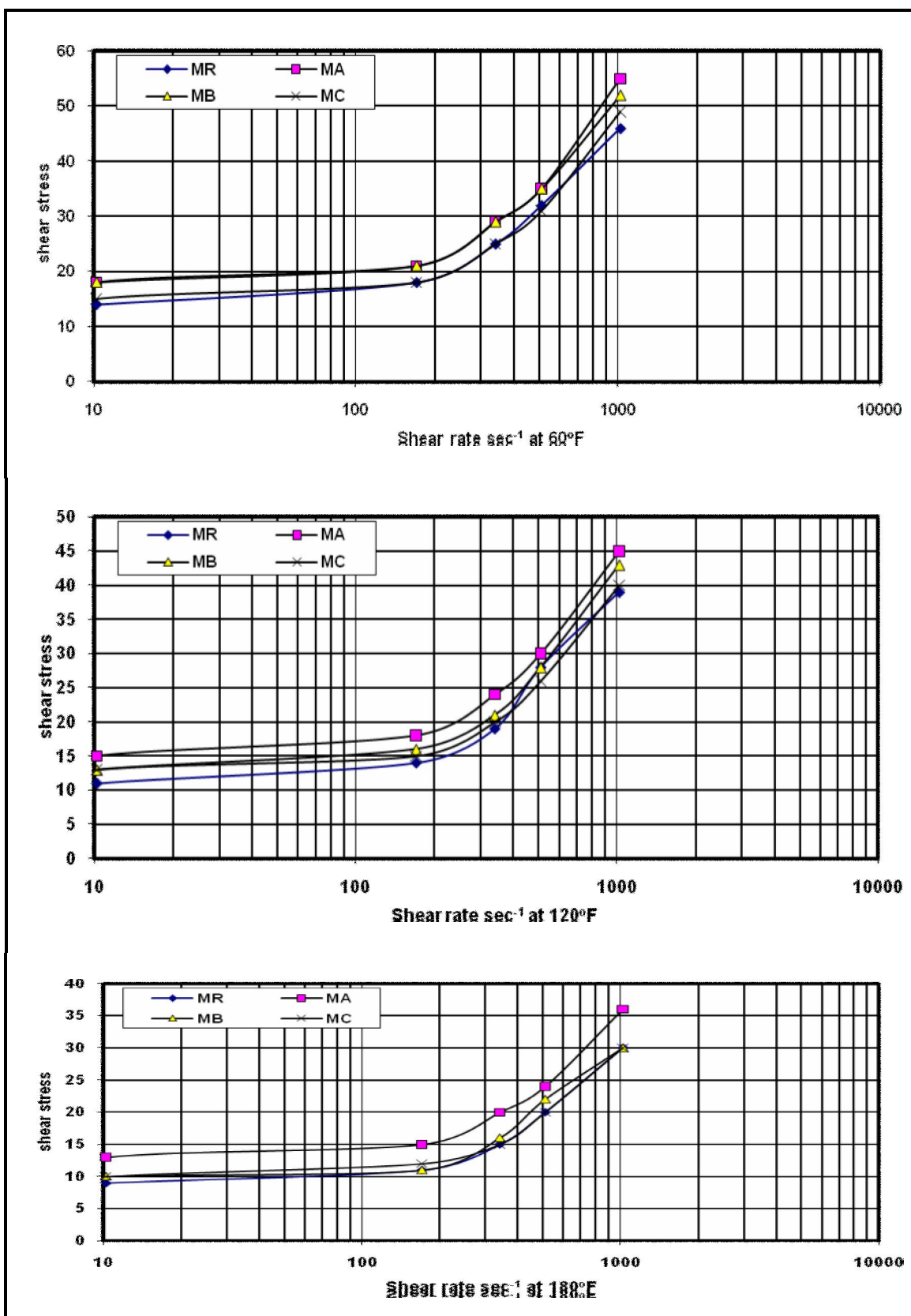


Fig. (7): Shear rate-shear stress relationship of water-Base muds formulated with newly viscosifiers A,B,C compared to reference sample mud (MR) under varying temperature

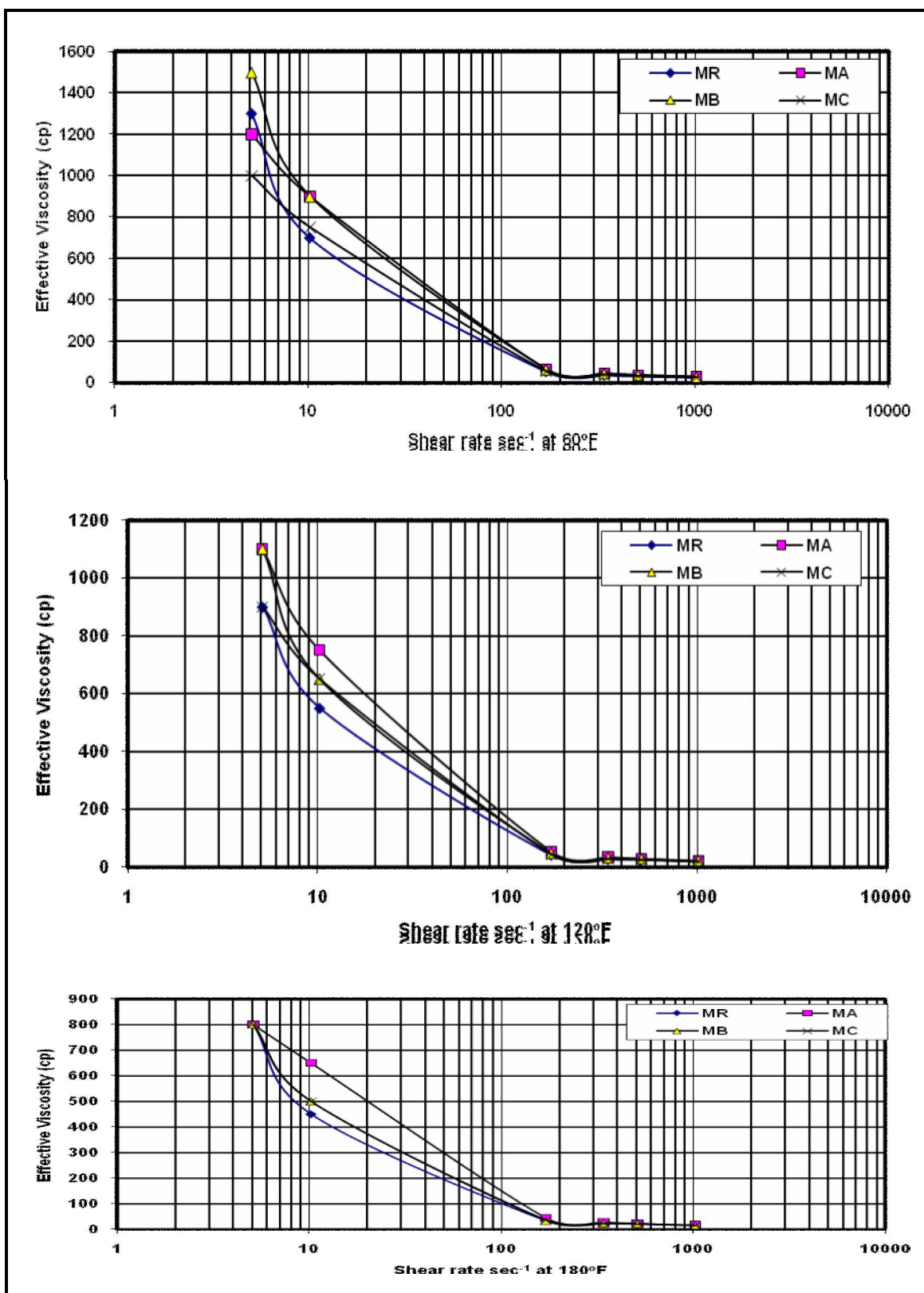


Fig. (8) Effective viscosity of water-Base muds formulated with newly prepared viscosifiers A, B, C compared to the reference sample mud MR under varying temperature

Conclusions:

From the obtained results we can conclude that:

1. All the Synthesized cationic surfactants showed good surface properties.
2. Experimental work and evaluation of the new synthesized cationic surfactants (A, B, C) show good results when utilized in the formulation of water –base mud as viscosifiers compared to the commercial viscosifier.
3. Rheological ,filtration properties of the most Synthesized viscosifiers performed a superior result compared to the commercial viscosifier

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