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To cite this article: Israa Mohammed Radhi *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **571** 012065

Influence of water in size of Synthesized Carbon Black Nanoparticles from Kerosene by Flame Method

Israa Mohammed Radhi[1], Firas H. Abdulrazzak [2] and Takialdin A. Himdan[1]

[11]*Department of Chemistry, College of Education for Pure Science, Ibn Al-Haitham University of Baghdad ,IRAQ*

[2]*Department of Chemistry, College of Education for Pure Science, Diyala University, IRAQ*

Corresponding author's e-mail: firas_habeb2000@yahoo.com

Abstract:

Black carbon nanoparticles BCNP were prepared from H_2O/kerosene by a flame method using a specific chamber homemade which designed to provide specific conditions. Methanol alcohol was used as a source for producing CO gas to reduce the oxygen on the reaction and to provide the atmospheric conditions. All the ratios of water 5.26%, 11.11%, 17.64%, 25% and 42.85% were succeeded to reduce the size of carbon black nanoparticles when mixed with kerosene. The diameter of carbon black nanoparticles was 67.61 nm with pristine kerosene which reduces to 33% (45.33 nm) when used 42.85% of DI water in mixture. The particles were characterized by X-ray diffraction, scanning electron microscopy which supplied with Energy-dispersive X-ray spectroscopy and surface area.

Keywords: Kerosene, distilled water, particle size, BET, BCNP.

1. Introduction:

Carbon one of widespread material in nature with verities in abilities to forming different compounds using hybridization in pure and mixture form such graphite structures and millions hydrocarbons compound. The elements with nano size shows unique properties which disappears or at least reduce at the classic level of materials [1]. The effect of gravity, with surface area and the number of active sites were responsible in the physical and chemical properties of nanomaterials NM [2]. Nano technology can deals with NMs at dimensions less than 100 nm to make ideal in industrial, medical and environmental applications. The applications confirm that NMs can enhance the maximum efficiency when may reach to 100%, which economically and practically required [3]. Carbon nano-materials CNM were considered ideal model for compounds with nanostructures, multiple formats and variant in characteristics behavior [4-5]. Actually chemical, mechanical, thermal

IOP Conf. Series: Materials Science and Engineering **571** (2019) 012065 doi:10.1088/1757-899X/571/1/012065

and electrical properties of CNMs determined through orientation and hybridization of carbon groups [6]. The behavior responsible to decide the possibility for using in different application. Black carbon (BC) represent common CNMs which consist [7] of different hybridization of carbon atoms when produced by decomposition of hydrocarbon materials. Black carbon nanoparticles BCNP is a traditional carbon form which manufactured in most conditions to forming specific behavior and properties of aggregates carbon nanoparticles. The applications of BCNP were represented by used as additives to rubbers when enhanced reinforcement, strength, and conductivity in additions to pigments for many purpose. In this work BCNPs were prepared from H_2O/kerosene by flame deposition method with CO atmosphere. The BCNPs were characterized by X-ray diffraction XRD, scanning electron microscopy SEM with Energy-dispersive X-ray EDX and surface area.

2. Experimental:

2.1Materials:

Kerosene was purchase from local market in Baghdad/Iraq without any purification. Methanol with more 99% in purities were supplied from Hyman, England. Aluminum foil which was used as surface for precipitation which purchased from local market with diameters (7 cm x 7 cm x 0.04 cm).

2.2Preparation of BCNPs:

The process of synthesized BCNPs from Kerosene with different ratios of H_2O was reported in figure 1. Pristine Kerosene and different ratios H_2O/kerosene were placed in laboratory lamp which equipped with filament made from cotton. The filament was soaked for 24 h in kerosene than switched on the heat lamp for 5 minutes to start the precipitation on plate of aluminum which fixed with distance 20 cm above the kerosene lamp. As-prepared nanomaterials were desperate by ultrasonic water bath (30 Hz) with 150 mL ethanol then, filtered and dried at 80 $^{\circ}$C for 4h.

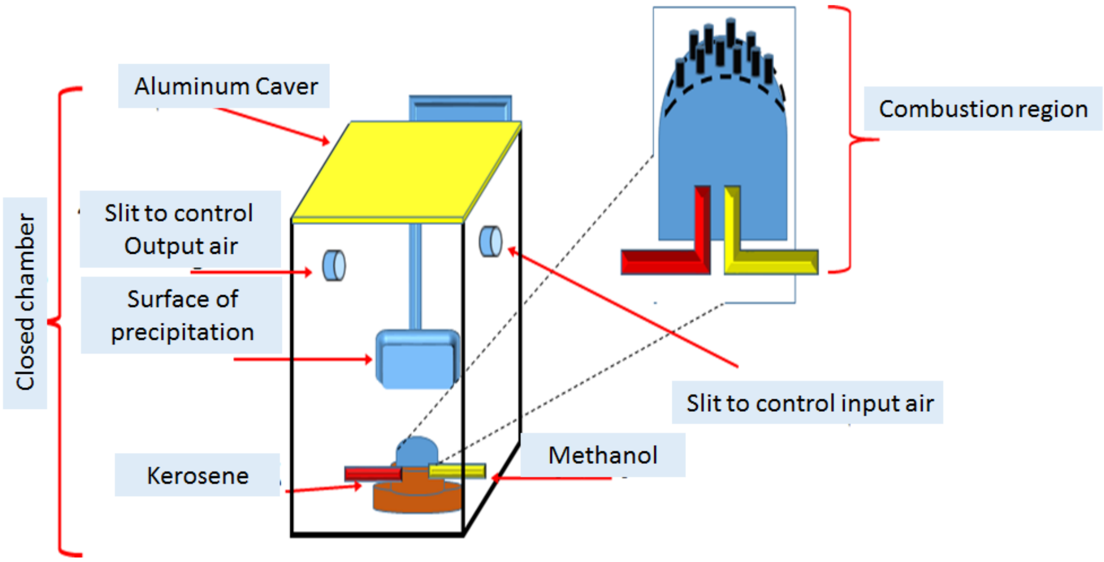

Figure 1: Schematic diagram of reactor and experimental setup for synthesized BCNPs.

3. Results and Discussion:

The X-ray diffraction patterns of prepared sample were taken by X-ray powder diffractometer (Rigaku Rotalflex) (RU-200B) using Copper at wavelength 1.54056 nm, and 0.15405 nm for $k_{\alpha1}$ $k_{\alpha2}$ respectively. The scan was taken between 10°- to 80° with increments of 0.02° with scan rate 5°/min. The morphological structure and continent materials was studied by a JEOL 7500F Field Emission scanning electron microscope which equipped with energy-dispersive X-ray (EDX).

Table1: summary for the ratios H_2O/kerosene with the average of precipitation materials.

Number	Samples	%H2O	% Kerosene	Average weight of precipitation materials (mg)
1	BCNP-a	0	100	420
2	BCNP-b	5.26	94.74	335
3	BCNP-c	11.11	88.89	256
4	BCNP-d	17.64	82.36	231
5	BCNP-e	25.00	75.00	195
6	BCNP-f	42.85	57.15	137

Figure 2 represent the XRD patterns for synthesized BCNPs which prepared from pristine kerosene and different ratios of H_2O/kerosene. The two peaks can be related to graphite [8] structures, whatever the first peak at ~24° for (002) planes is more intense than the second plane (010) at 43° when refer to hexagonal graphite lattice [9]. The intensities and width for the two peaks of six samples show variance in value as reported in table 2. As we reported in our previous work the broad peak arises as a result of disorder in sp^2 hybridized carbon with σ and π bonding [10].

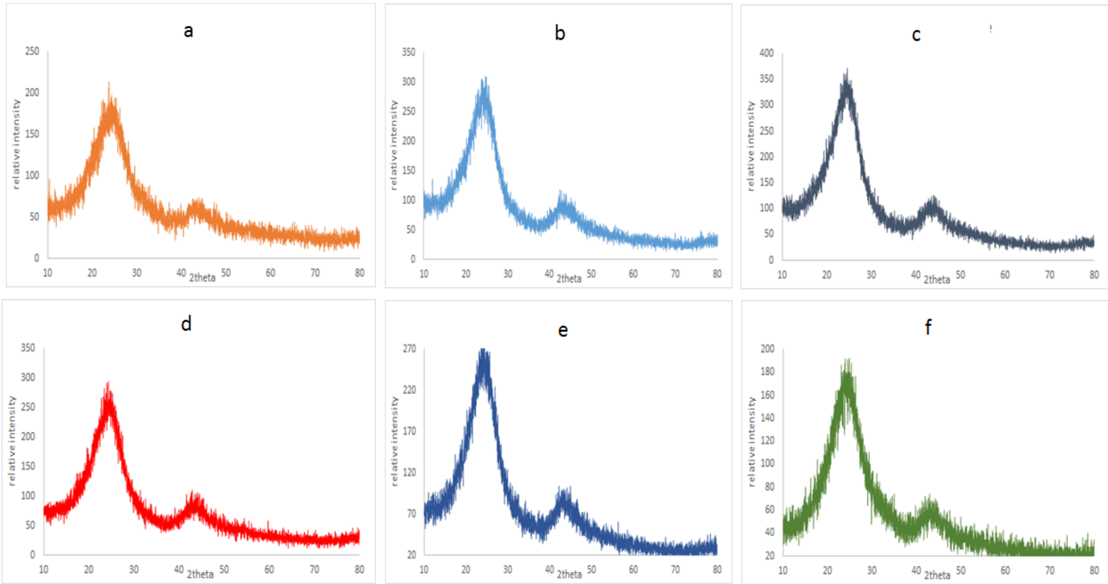

Figure 2. XRD patterns of BCNP prepared from (a)-pristine Kerosene and different ratios of H_2O with Kerosene (b) -5.26%H_2O/kerosene, (c) -11.11%H_2O/kerosene, (d)-17.64%H_2O/kerosene, (e)-25%H_2O/kerosene and (f)- 42.85%H_2O/kerosene in CO Atmosphere.

Table 2: summary of position and relative intensity of peaks for the six samples BCNPs.

Samples	First 2Θ	Relat. Intensity	FWHM = 2Θ	Second 2Θ	Relat. Intensity	FWHM = 2Θ
BCNP-a	23.76	118	6.30	43.96	29	4
BCNP-b	24.54	186	7.46	43.8	43	3.29
BCNP-c	24.94	242	6.12	43.44	38	2.02
BCNP-d	25.24	188	6.36	43.78	42	2.12
BCNP-e	25.20	170	6.60	43.74	42.19	2.4
BCNP-f	25.15	194	7.01	43.60	34.41	2.6

The first peaks at 2Θ≈ 24∘ shows positive deviations which increase with increasing the ratios of H_2O with Kerosene in addition to increasing the width and intensities for the peaks as compare with BCNP-a. The second peaks at 2Θ≈ 43∘ did not shows clear change which may related to lower intensity and width.

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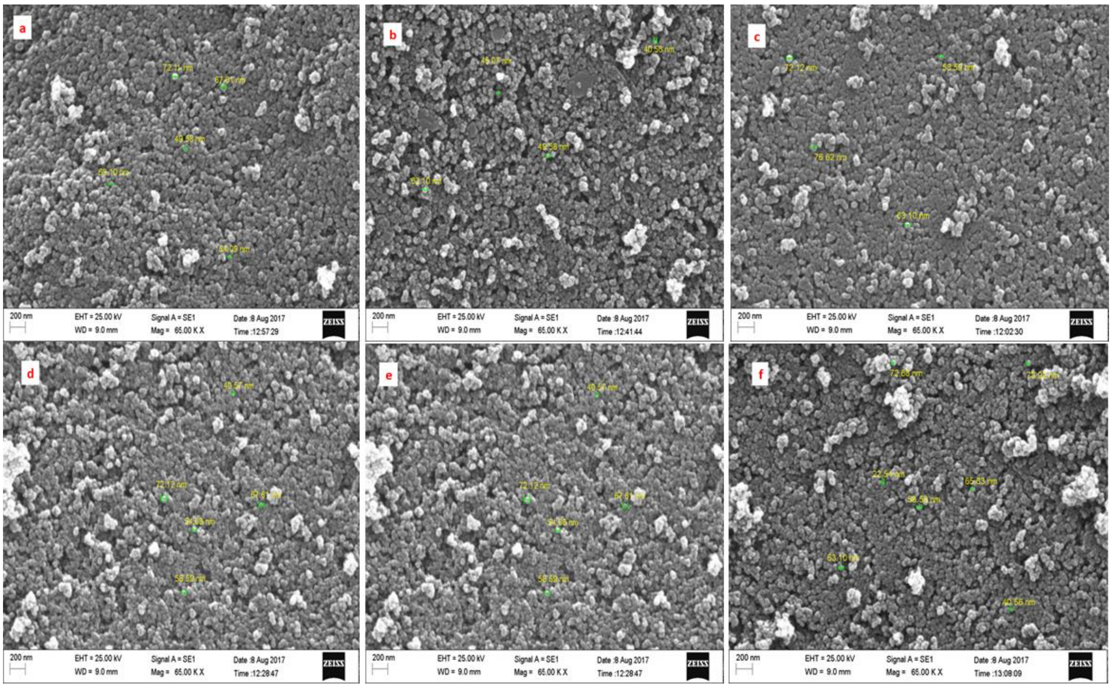

Figure 3. SEM image for BCNP prepared from pristine Kerosene BCNP-a and different ratios of H2O with Kerosene: (b) -5.26%H_2O/kerosene, (c) -11.11%H_2O/kerosene, (d)-17.64%H_2O/kerosene, (e)-25%H_2O/kerosene and (f)- 42.85%H_2O/kerosene in CO Atmosphere.

The surface morphology of the samples were represented in figure 3 which shows the diameters of BCNPs were ranging from 25 to 74 nm with more variance in diameter when used pristine Kerosene as source of carbon. The results show that diameters were more regular when ratios of H_2O increase in the mixture of Kerosene. The elemental cotenant was performed by EDX analysis for the six samples were represented in Fig.4. The synthesized BCNP shows pure carbon without any impurities which contained 100% carbon with change in ratios of carbon with variance in ratios of oxygen.

Table 3: the average of produce weight and particle size of BCNPs.

sample	Ratios of H_2O	Average of produces BCNP (g)	Average of particle size for BCNP (nm)
BCNP-a	0.00%	0.810	67.61
BCNP-b	26.51%	0.680	66.32
BCNP-c	11.11%	0.501	61.29
BCNP-d	17.64%	0.452	58.59
BCNP-e	25.00%	0.291	49.57
BCNP-f	42.85%	0.207	45.33

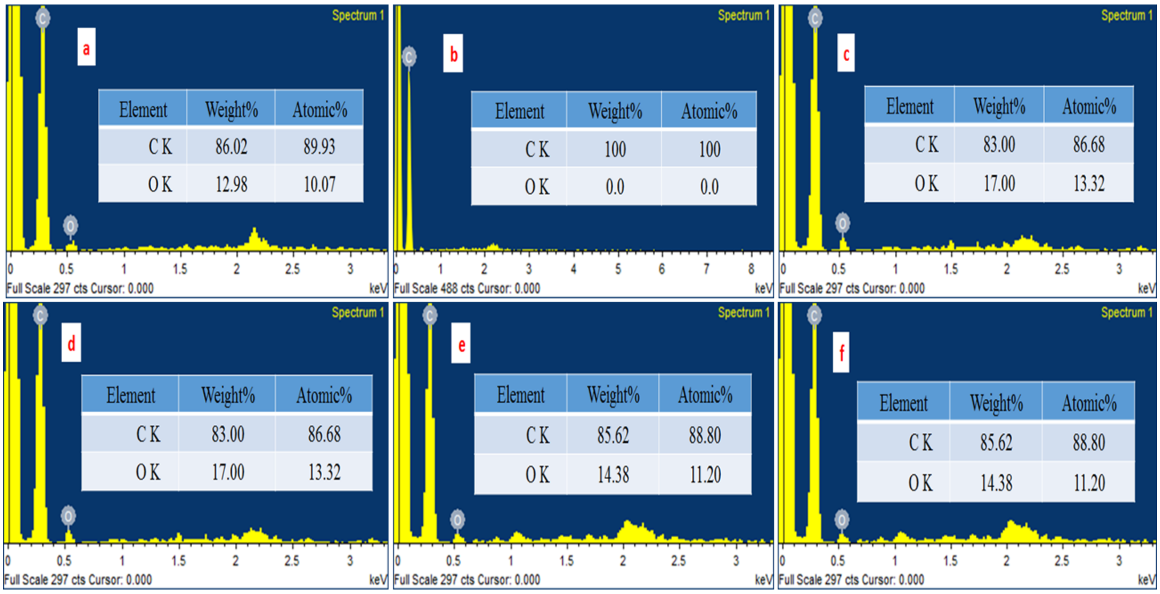

Figure 4. EDX analysis of BCNP prepared from pristine Kerosene BCNP-a and different ratios of H_2O with Kerosene: (b) -5.26%H_2O/kerosene, (c) -11.11%H_2O/kerosene, (d)-17.64%H_2O/kerosene, (e)-25%H_2O/kerosene and (f)-42.85%H_2O/kerosene in CO Atmosphere.

The values of surface area BET were measured for all the samples represent in figure 5. The surface area of BCNPs were shown increase with exist and increase the ratios of DI-H_2O which proportion with degrees the calculated particle size.

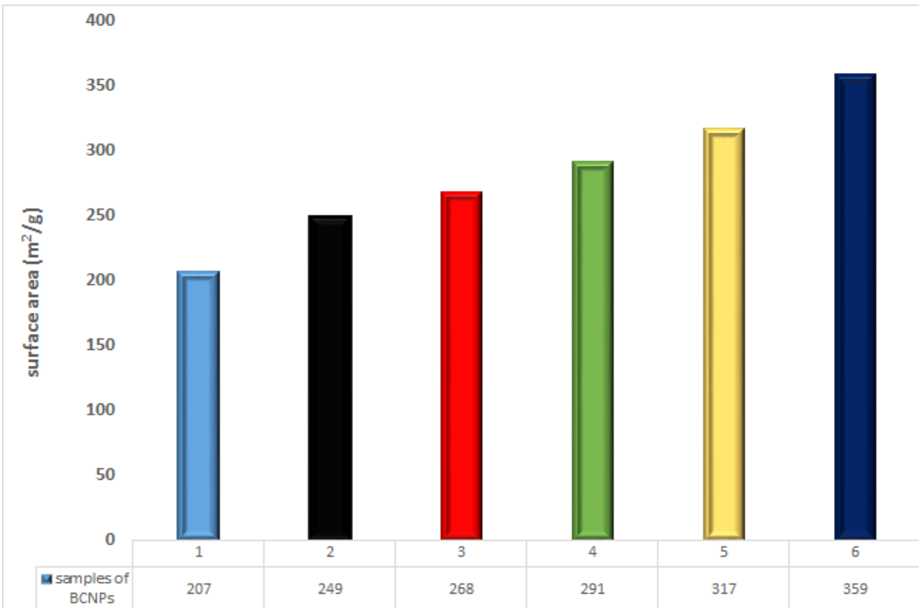

Figure 5: The skim of surface area for synthesized BCNPs

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4. Mechanism of growth:

Theoretically onion particulars could forming homologous series, of fullerene which stable with carbon layers [11] equivalent to graphite in π-electronic structure and 3-dimensional spherical shapes. The most an acceptable molecular model of the spiral intermediates [12] refers to a path of growth around a fixed center point by free radical centers. The conjugation of carbon atoms responsible to enhance stabilized the free radicals [13] that could be produced under the incomplete combustion conditions. The free growth of radicals forming primary graphene layer that able to aggregate to complex structure and deforming balls [12-13] by physical and chemical forces. As mentions previously incomplete combustion of kerosene which is mixture of hydrocarbon materials $C_xH_yO_z$ mostly forming fragments of free radicals with different and variant in molecular mass. The fragments responsible to forming the primary graphene layers as shown in mechanism below which produce different species of fragments:

$$C_xH_yO_z + 1/2O_2 \rightarrow CO^n + C_{x-1}{}^nH_yO_z$$

$$C_{x-1}{}^nH_yO_z \rightarrow (C_{x-1}H_yO_z)^n$$

$$C_xH_yO_z + 1/2O_2 \rightarrow C_xH_{y-1}{}^nO_z + OH^n$$

$$C_xH_{y-1}{}^nO_z \rightarrow (C_xH_{y-1}O_z)^n$$

$$C_xH_yO_z + 1/2O_2 \rightarrow C_xH_yO_{z-1}{}^n + O^n$$

$$C_xH_yO_z{}^n \rightarrow (C_xH_yO_{z-1})^n$$

The primary fragments with different charge n when n refer to free radical, cationic or anionic. The decomposed kerosene produce species of free radical which start [13-14] to react with each other in sp^2 hybridization and forming many primary layers of benzene ring. All of benzene ring acts as nuclei when grow as planer net sheet or spherical structure that mostly tend to form aggregates with growth surface. Water is a polar molecule with stronger intermolecular forces than [14] the mixture of different hydrocarbon compounds and different molecular masses represent by kerosene. The water molecules can inter between layers which characterized by variance velocity value leading to reduce viscosity at normal temperature and pressure for mixture. This interaction causing new behavior for mixture of kerosene within water when decomposed in smaller groups forming less size of free radicals. Thus the water plays two effect: the first was reduces the molecular interaction between component of kerosene, while the ether shown quencher for free radicals which limit the growth of BCNPs. Figure 3 of SEM images shows that increase the ratios of water with kerosene causing digresses the particle size and make it more regular BCNPs as reported in table 3.

5. Conclusion:

The process of forming BCNPs influence with the conditions of carbon as free radicals when built the nanoparticle carbon with different orientation and hybridization. In this work, the two atmosphere CO and O_2 were chosen to produce black carbon nanoparticles which shows influence in size. The atmosphere condition of kerosene/air diffusion flame to generates BCNPs which is cheap and safe to produce BCNPs with the abilities to control the particle size and the amount of product. The CO gas succeeded to reduce the practical size of BCNPs with using simple strategy in reaction without any complication for the method.

References:

1-Gregory G., Aram S. S., "The physics of macro-, micro- and nanomaterials", physicalia mag, 27, pp. 131-141, 2005.
2- Schmid G (ed) (2011) Nanoparticles: From Theory to Application. Wiley-VCH, Weinheim, Germany.
3- Zhang M., Naik R., Dai R. (2016),"Carbon Nanomaterials for Biomedical Applications", Springer Series in Biomaterials Science and Engineering.
4-Braulio C. B., Ivan D., Samira H., Marc J. M., and Sergio O. M. C. ,"Review—Covalent Functionalization of Carbon Nanomaterials for Biosensor Applications:. Electrochem. Soc.165 (3): B103-B117, 2018.
5-Bal-Ram A., Maduraiveeran G. and Aicheng C.," Carbon Nanomaterials Based Electrochemical Sensors/Biosensors for the Sensitive Detection of Pharmaceutical and Biological Compounds ", Sensors, 15, pp. 22490-22508, 2015.
6-Mauter, M. S.; Elimelech, M. E.,"Environmental Applications of Carbon-Based Nanomaterials", Sci. Technol. 2008, 42(16), pp. 5843–5859. doi: 10.1021/es8006904.
7-Mohan A. N. and Manoj B ," Exploration of Carbon Nano Dots in Hydro Carbon Soot and Carbon Black ", Res. J. Chem. Envi. , 21(2) February, pp. 1-6, 2017.
8- Reznik D., Olk C.H., Neumann D.A.," X-ray powder diffraction from carbon nanotubes and nanoparticles," Phys. Rev. B 52, pp.116–124, 1995.
9- Yicheng D., Chuji W., Hossain T., Zhiyong C., Xiaojian L., Jilei Z. and Qiangu Y.., "Synthesis of carbon-encapsulated metal nanoparticles from wood char", Forest Prod. J., 60 (6), pp. 527-533, 2010.

10-J. Dore," structural studies of carbon nanotubes and related materials by neutron and x-ray diffraction", Acta Physica Polonica A, 98(5), pp.495-504, 2000.
11- Yoshida M., Ōsawa E.," Molecular Mechanics Calculations of Giant- and Hyper fullerenes with Eicosahedral Symmetry", Fullerenes *Sci*. Technol. 1, pp. 55-74, 1993.
12-Masaki O. and Eiji Ō.,"Carbon Nanotechnology', Dai, L. (Ed.), Chapt. 6, pp. 127-151, Elsevier: Dordrecht, 2006.
13- Homann K. H.,"Fullerenes and Soot Formation- New Pathways to Large Particles in Flames Angew. Chem. Int. Ed. 37, 1998, 2434-2451.
14- Stewart A.C. , EI-Hamouz A.M. & Davies G.A. ," effect of chemical additives on the stability of Kerosene-water dispersions", J. Disp. Sci. Tech., 17(6), pp. 675-696, 2007.