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The study of stability of the ferric oxide sols by zeta /ζ/ potential

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Abstract: In this study ferric oxide sols solutions were prepared in presence of different electrolyte and their zeta potentials were measured by simplified electrophoreses method with protective semi membrane filters. The stability of these sols solution was affected by particles size and electrolyte pH.

Keywords: Electrophoresis, isoelectric point, nano particles, dispersion system

INTRODUCTION

Electrokinetc study, in particular, the study of stability of a colloid system by zeta potential has done at different outcome in Overseas countries where basic research is highly developed and were achieved considerable results [1].

For example, the Russian and Ukrainian scientists Levitin Ye.Ya., and Vyedyeryikova I.A study zeta potential of iron oxide (FeO and Fe_2O_3) mixtures of colloidal solution increase 45% by 0.5% hydrochloric acid solution and 55% by 3% sodium olyeatyn water solution [2].

Austrian and Hungarian scientists Jasmina Salopek, Nikola Kallay, and Davor Kovačević iron oxide sols study the relationship between the surface potential and the zeta potential is given a description of the electricity interfacial layer [3].

Japanese scientist Masataka Ozaki solution of iron oxide sols of zeta potential depends small part on the type of image structure has been found [4]. However, in Mongolia research in this field has not been done because it is difficult to measure the potential without appropriate tools. And it's a pilot study was made at the laboratory of Japan.

In this short report, we described about a simple and convenient apparatus for the measurement of electrokinetic mobility using moving boundary method. In the future, we are planned to be used the electrokinetic potential to study the properties of the Mongolian soil colloid.

EXPERIMENTAL

Mamerials and methods: In this study, we tried to measure the zeta potential of colloid solution and its stability in laboratory condition using simplified electrophoreses. Hence, ferric oxide sols solution was prepared and its zeta potential measured. Electron-microscopic photo is shown (Fig. 2).

The measurement was made in the electric field 2-9 volt/cm which is regulated by the constant electric current generator attached to electrophoresis equipment. The temperature controller of the

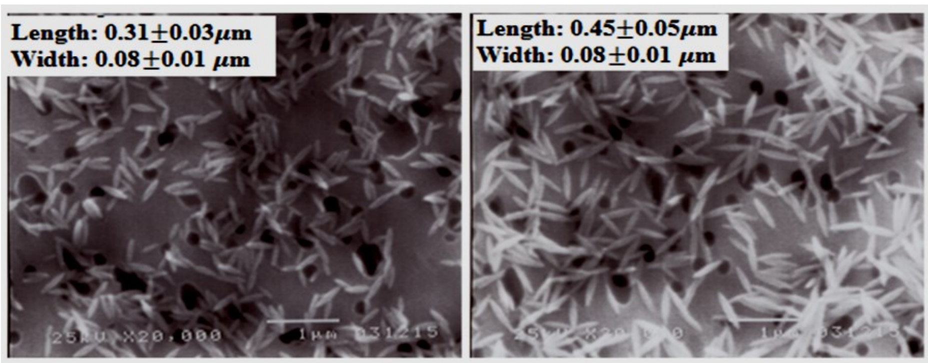

Fig. 2. Ferric oxide (Fe_2O_3) particles SEM picture

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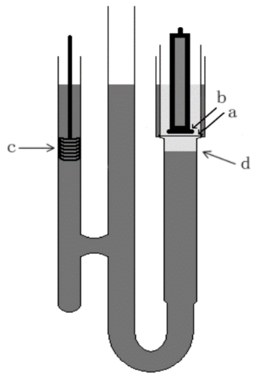

Fig. 3. General scheme of measuring instruments used the experiment
a: *Semi-permeable wall /membrane /*
b: *A platinum electrode*
c: *Silver-silver chloride electrode*
d: *Surface displacement*

electrophoresis equipment started 30-1h before the start experiment to keep temperature at (25±C^o). Moreover, semi-permeable wall was placed before the electrode to reduce electrode effect on particles and enhance boundary of transfer solution surface (Figure 3) [5, 6].

Also placed semi-permeable membrane slightly reduced the electrode effect on dispersal system particles [7]. The layer migration with regular time period is measured and eventually the electrophoresis speed is calculated. Moreover, from migration the zeta potential can be calculated by Smolovskii equation [8].

E- Electromotive force (V/cm)

$$E = \frac{1}{K \times S_C} \times i \quad \text{and} \quad U = \frac{\upsilon}{E}$$

where:

K - Electrical conductivity of the solution ($cm^{-}1\Omega^{-1}$)
l - Length (cm)
S_c- Tank area (cm^2)
i - Amperage (A)
U - Shift (B/C)
υ - Transfer velocity (cm/c)
ζ – Zeta potential (mV)

$$\zeta = \frac{\eta \times E}{\varepsilon_0 \varepsilon_r} = 12.8 \times U$$

η - The coefficient of viscosity of the solution
ε_0- Vacuum dielectric quality ($8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$)
ε_r- Solvent relative dielectric access and quality (78.5)

RESULTS AND DISCUSSION

Three samples of ferric oxide sols were prepared and sols particles size (length and width) was measured by the electron microscopy as well the zeta potential obtained by electrophoreses method are shown in the Table 1. Experimental results revealed correlation between the value of zeta the potential and colloid particles size.

The ferric sols solution with concentration of 1µM, 5 µM and 10 µM (each 3 times) in the presence of hydrochloric acid were prepared and their zeta potentials are determined. Also, a correlation between the zeta potential and pH was studied using

Table 1. The relation between the zeta potential and colloid particle size

Dispersion of ferric oxide	Length, Mm	Width, Mm	ζ-potential defined by precipitate potential, mV	ζ -potential determined by electrophoresis, mV
Sample 1	0.21±0.03	0.08±0.01	40.0	51.0
Sample 2	0.31±0.03	0.08±0.01	42.7	42.6
Sample 3	0.45±0.05	0.08±0.01	69.8	65.2

Table 2. Influence of the solution medium on zeta potential

Dispersion solution of ferric oxide, µM	ζ-potential, mV	pH of dispersion solution of ferric oxide		ζ-potential, mV
		Dispersion solution	pH	
1µM HCl	64.5	1µM NH_4OH	9.75	-34.8
1µM HCl	67.5	2µM NH_4OH	9.92	-38.9
1µM HCl	53.6	1µM NaOH	7.4	27.5
5µM HCl	54.0	0.1µM NaOH	7.25	19.5
5µM HCl	52.2	1µM HCl	3.51	69.2
5µM HCl	59.9	0.5µM HCl	3.14	67.3
10µM HCl	62.6	10µM HClin the10µM KCl	3.43	38.9
10µM HCl	65.5	10µM HCl in the 5µM KCl	3.67	30.9
10µM HCl	64.1			

prepared ferric sols in the presence of different electrolytes (Table 2).

When electrode is connected t pole same as charged particles, the latter's migration leads to form **d** layer. The zeta potential can be calculated by measuring this layer migration for certain time period. Furthermore, migration distance and time should be directly correlated, if electrophoreses run properly [9]. This trend also observed during our experiment (Figure 4).

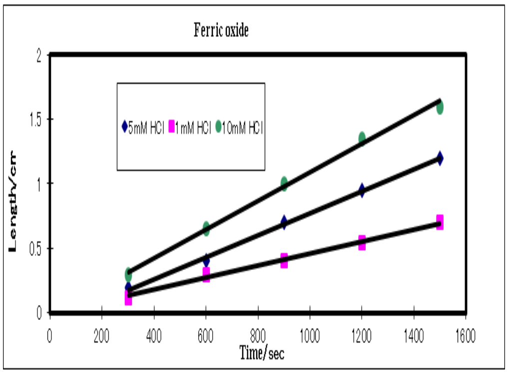

Fig. 4. The depending correlation of d-transition surface from time

The zeta potential value depends on many factors including solution pH, temperature, presence of electrolyte, as well surface active compounds in the colloid system. For instance, value of the zeta potential depends on solution pH, once net charge of the colloid particles changes the zero potential value equalizes to zero and colloid system loses the stability. That pH value is known the isoelectric point (Fig. 5) [10, 11].

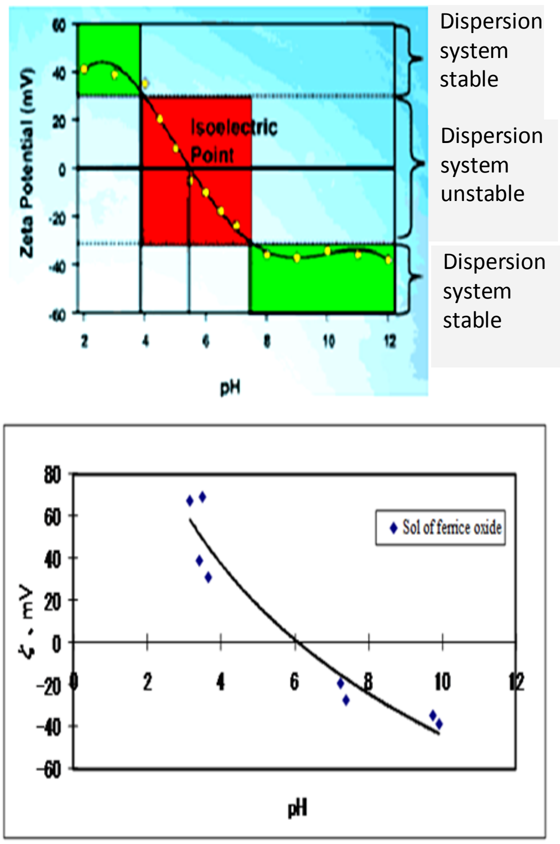

Fig. 5. Zeta potential and pH

Results concealed that ferric oxide zeta potential fluctuates between 52.2-67.7mB depending on the acidity of the solution. In contrast, when solution acidity reduces and pH increases, value of the zeta potential reduces from +69.2mB to -38.9mB. The graph, created from these data, exposed that when the sols pH=6.2 the value of the zeta potential reaches to 0. Another words, the colloid particle loses its charge and gets close to its isoelectric point. Subsequently this point, the zeta potential possesses negative value meaning sols particles has changed.

We measured the zeta potentials of sols used for above experiments by the Pen Kem System-3000 to evaluate our research data. The below figure clearly shows that our experimental data were very close to those data obtained the Pen Kem System.

Also, research results, studied by researchers Levitin E.Y. and Bedernikova E.A. in suspended particles

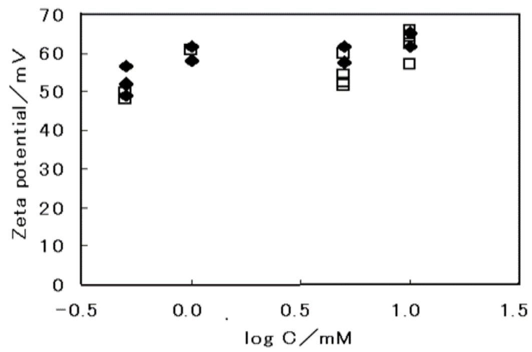

Fig. 6. The comparison of the measurement results (◆: Our measurements, □: Pen Kem System-3000)

($FeO+Fe_2O_3$), reveal that the zeta potential of these particles also stabilized in presence of the hydrochloric acid [12].

CONCLUSION

1. General conditions of simplified electrophoreses were determined and semi-permeable membrane used to increase electrophoreses speed and make clear the migration layer.
2. The size and shape of particles influence on their migration. It could be explained by the directive nature of the particles.
3. The value of the zeta potential of ferric oxide, prepared in solution with various concentration of hydrochloric acid, were fluctuated between 52.2-67.5mV depending on acidity of the solutions.
4. Between pH=3.5-4.5 colloid particles of ferric oxide are charged positively while pH=6-11 negatively. It is determined that at pH =6, colloid particles lose their charge (ζ=0) and match to their isoelectric point.

5. It the end, this research proves dispersal system can be studied as well nano particles can be measured by electron microscope as set colloid particle size.

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