

The Oxyhydrates Colloids Particles Electrical Oscillations

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Abstract. The change in colloidal systems is determined by the processes of chemical kinetics. It is necessary to consider the electrical interaction of colloids in a viscous (aqueous or other) medium in order to determine the interacting chemicals. This can be achieved by applying mathematical modelling of the processes. We used the Vlasov-Maxwell kinetic equation. We have constructed a solution to the problem of the kinetic equation in the approximation of colloidal plasma two-fluid hydrodynamics. The agreement with the experimental data follows from the constructed solution – the existence of a spontaneous electric nanocurrent in a polar colloidal system.

INTRODUCTION

Consider a colloidal system in an aqueous solution - such that water is directly involved in chemical reactions. Such a system is inevitably an electrochemical system due to the significant dipole moment of water molecules. The system is electrical, thus.

Every electrical system is unstable due to Earnshaw's theorem [1]. This means that the entire system or its elements are changing somehow their structure, configuration, and, possibly, chemical composition. Consequently, certain fluctuations in the aquatic environment are inevitable.

The oscillations themselves are widely known, and are not of particular interest from a chemical point of view. Therefore, we propose to consider a narrower class of chemical systems. Their instabilities energies should be comparable with these of molecular interactions energy, so electrical instabilities can also influence the chemical substances interaction process.

Some particles links are very strong. Such a particle (or a large particle fragment) can be considered as a whole. However, such a particle or fragment has a certain electrical moment and mass. We take into account electric moment by introducing an effective electric charge. Thus the problem is reduced to the motion of free charged electric particles.

COLLOID

Consider a colloidal substance. Let us take the colloidal chain geometric size (or mass) as the central characteristic of the colloid [2]. Therefore, an increase in the polymer chains lengths of the colloid is the central process of chemical kinetics.

We use a kinetic approach to describe the colloid polymer chain growth, according to which all chemical interactions are uniquely determined by the chemical process of chain development. We introduce the phase of the process Φ to characterize the kinetic approach. The phase of the process is closely related to the colloidal particle mass.

Let us distinguish three stages in the colloidal chain life.

First step. The colloidal chain grows rapidly, all chemical bonds are very strong, the oscillatory process has little or no effect on the colloid development. Let the phase in this process change to some value Φ_0 . We do not consider this step, since the oscillatory processes and the chemical ones themselves, although they are connected, are difficult to trace, physical processes and chemical processes seem to go on by themselves. So their mutual influence is weak and negligible.

Second phase. The colloidal chain growth is significantly slowed down, for polymer chain becomes too long and too shielded by small charged particles. So the attachment of new colloidal fragments becomes much less probable, and not all the resulting chain extensions are stable. The role of oscillations becomes significant at this micelle's existence stage.

Stage three the existence of a colloid - an "aged" colloid. Its polymer chains are too long and there are too few small fragments left - in this case, oscillations are also inevitably present, but it is difficult to observe them due to their weak manifestation (too small amplitude) and too low frequency. We will not consider this colloid's existence either stage.

It is easy to see that any change in the colloidal chain chemical property leads to the chemicals certain amount generation. These substances have a positive or negative electric charge due to the polar nature of a colloid. That is, charge separation occurs, and two oppositely charged substances appear, plasma in a liquid. Since the current is experimentally confirmed [3], that is, the movement of a free or effective charge, it seems to us that the propagation of the appeared plasma wave matters.

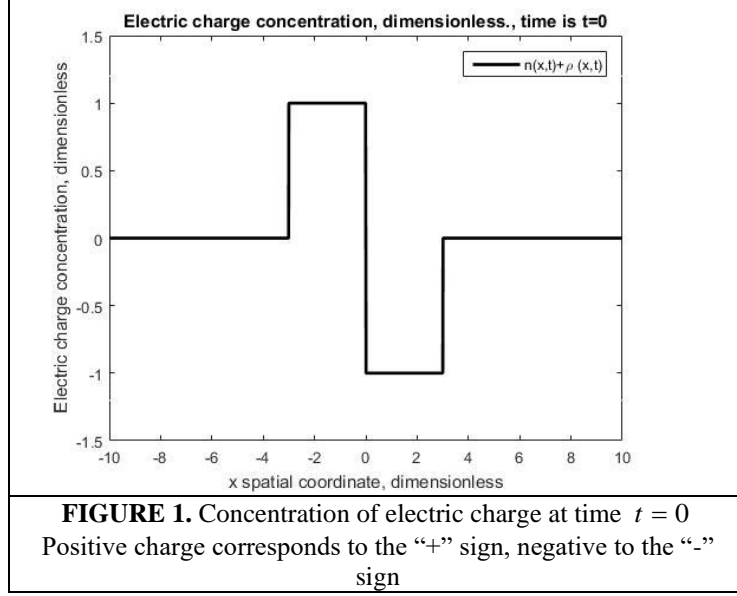
MATHEMATICAL MODEL

Consider the charges simplest, one-dimensional motion. We proceed from the collisionless equations two-fluid hydrodynamics [4]. Let us denote the concentration of the liquid corresponding to the positive charge as the function $\rho(x,t)$, and its velocity $u(x,t)$. Here x - spatial coordinate, $x \in (-\infty; +\infty)$, $t \in [0; +\infty)$ - is time. Accordingly, the concentration of negatively charged liquid $n(x,t)$ and its velocity is $v(x,t)$.

We assume that at the time initial moment $t = 0$ charged liquids are distributed according to the law:

$$\rho(x,0) = \begin{cases} 0, & x < -l, \\ \rho_0, & -l \leq x \leq 0, \\ 0, & x > 0, \end{cases} \quad n(x,0) = \begin{cases} 0, & x < 0, \\ \rho_0, & 0 \leq x \leq l, \\ 0, & x > l, \end{cases}$$

where l - some length (Figure 1).



We assume that the rectangular shape of the charged concentration liquid persists over time, only its dimensions (height and length, as well as the concentration rectangle location) change. The calculation shows that this does not contradict the problem.

Therefore, at time subsequent moments, we assume that the charged liquid concentration functions $\rho(x,t)$ and $n(x,t)$ are defined by formulas

$$\rho(x,t) = \begin{cases} 0, & x < x_1(t), \\ \rho_0(t), & x_1(t) \leq x \leq x_2(t), \\ 0, & x > x_2(t), \end{cases} \quad n(x,t) = \begin{cases} 0, & x < x_3(t), \\ \rho_0(t), & x_3(t) \leq x \leq x_4(t), \\ 0, & x > x_4(t), \end{cases}$$

where function $\rho_0(t)$ is the same for both charged liquids due to the problem symmetry, and the functions $x_1(t), x_2(t), x_3(t), x_4(t)$ set the boundaries of the concentration rectangle. These boundaries are flexible.

Thus, we have to determine these functions based on the two-fluid hydrodynamics equations for functions: $\rho_0(t), x_1(t), x_2(t), x_3(t), x_4(t)$.

The two-fluid collisionless hydrodynamics equations system has the form:

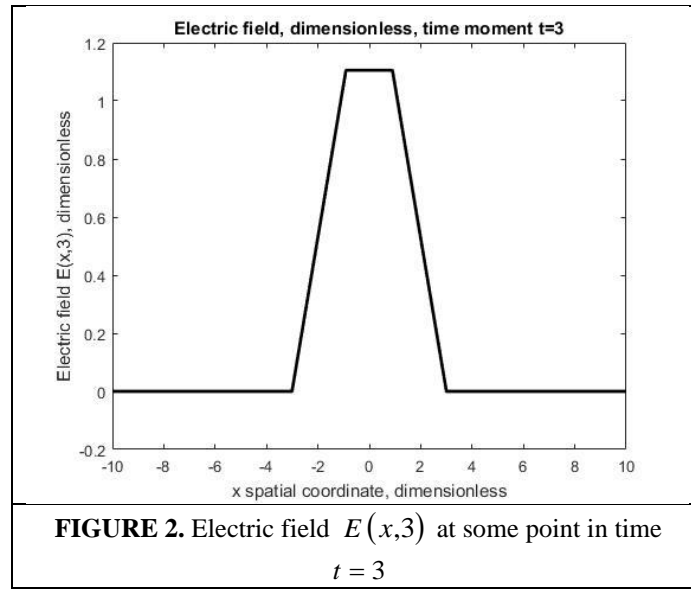
$$\begin{cases} \frac{\partial v(x,t)}{\partial t} + v(x,t) \frac{\partial v(x,t)}{\partial x} = -\frac{q}{m} E(x,t), & x \in (-\infty; +\infty), t > 0, \\ \frac{\partial u(x,t)}{\partial t} + u(x,t) \frac{\partial u(x,t)}{\partial x} = +\frac{q}{m} E(x,t), & x \in (-\infty; +\infty), t > 0, \\ \frac{\partial \rho(x,t)}{\partial t} + u(x,t) \frac{\partial \rho(x,t)}{\partial x} = -\rho(x,t) \frac{\partial u(x,t)}{\partial x}, & x \in (-\infty; +\infty), t > 0, \\ \frac{\partial n(x,t)}{\partial t} + v(x,t) \frac{\partial n(x,t)}{\partial x} = -n(x,t) \frac{\partial v(x,t)}{\partial x}, & x \in (-\infty; +\infty), t > 0, \\ \frac{\partial E(x,t)}{\partial x} = 4\pi q (\rho(x,t) - n(x,t)), & x \in (-\infty; +\infty), t > 0. \end{cases} \quad (1)$$

Here the notation is used: q – particle charge (we assume that the both signs charges and masses are the same), m – its mass, $E(x,t)$ – electric field.

Let us introduce the notation $\omega_0^2 = \frac{4\pi q^2}{m}$. Accordingly, the electric field determined by charges rectangular forms has the form:

$$E(x,t) = 4\pi q \rho_0(t) \begin{cases} 0, & x < x_1(t), \\ x - x_1(t), & x_1(t) \leq x < x_3(t), \\ x_3(t) - x_1(t), & x_3(t) \leq x \leq x_2(t), \\ x_3(t) - x_1(t) - x, & x_2(t) \leq x \leq x_4(t), \\ 0, & x > x_4(t), \end{cases} \quad (2)$$

provided that the boundaries $x_i(t)$ obey the inequality: $x_1(t) < x_3(t) < x_2(t) < x_4(t)$. Note that the charge indicated location for Figure 1 corresponds to this boundaries location in a certain time interval $t \in [0; t_0]$. Let's find this time interval and find out what the moving boundaries further location will be. Electric field type $E(x,t)$ for this time interval is shown in Figure 2.



In accordance with formulas (1, 2), we obtain that the equation for the positive charge speed will have the form:

$$\frac{\partial u(x,t)}{\partial t} + u(x,t) \frac{\partial u(x,t)}{\partial x} = \omega_0^2 \rho_0(t) (x - x_1(t)). \quad (3)$$

Note that according to Figure 2 the electric field is equal to zero at the point $x_1(t) = -l$. Consequently the equality $x_1(t) = -l$ will not change during the entire time period $t \in [0; t_0]$, due to the absence of the particles initial velocity at this point, until the border $x_3(t)$ will not "catch up" the border $x_1(t)$. Since we restrict our consideration to this particular interval, we may assume $x_1(t) = -l$.

We also do not know the function $\rho_0(t)$ in equation (3).

We obtain the equation for characteristics solving (3):

$$\frac{d^2 x(t)}{dt^2} = \omega_0^2 \rho_0(t) (x(t)+l) \quad (4)$$

Suppose that we know the solution to the homogeneous equation (4) and it can be represented by a functions pair $\{F_1(t), F_2(t)\}$, $F_1(0) = 0$, $F_1'(0) = 0$, $F_2(0) = 1$, $F_2'(0) = 0$. Then solution to (4) has the form:

$$x(t) = C_1 F_1(t) + C_2 F_2(t) - l.$$

Hence it follows that $u(x,t) = C_1 F_1'(t) + C_2 F_2'(t)$, and from the initial condition and the properties of the functions at zero we obtain: $C_1 = 0$. Eliminating arbitrary constants from the equations for x and $u(x,t)$, we have

$$u(x,t) = (x+l) \frac{F_2'(t)}{F_2(t)}.$$

Let us now solve the equation for $\rho(x,t)$:

$$\frac{\partial \rho(x,t)}{\partial t} + u(x,t) \frac{\partial \rho(x,t)}{\partial x} = -\rho(x,t) \frac{\partial u(x,t)}{\partial x}, \quad x \in (-\infty; +\infty), t > 0. \quad (5)$$

Its characteristics will obey the ratios: $\frac{dt}{1} = \frac{dx}{u} = \frac{d\rho}{-\rho \frac{\partial u}{\partial x}}$,

We obtain the relations to find the characteristics:

$$\begin{cases} \frac{dx(t)}{dt} = (x+l) \frac{F_2'(t)}{F_2(t)}, \\ \frac{d\rho}{dt} = -\rho \frac{F_2'(t)}{F_2(t)}, \end{cases}$$

and the solution: $x = C_1 F_2(t)$, $\rho = \frac{C_2}{F_2(t)}$.

We come to the conclusion that $\rho = \frac{\rho_0}{F_2(t)}$, taking into account the initial conditions.

Returning to equation (4), we obtain a nonlinear equation for determining the function $F_2(t)$:

$$\begin{cases} \frac{d^2 F_2(t)}{dt^2} = \frac{\omega_0^2 \rho_0}{F_2(t)} (F_2(t)+l), \\ F_2(0) = 1, F_2'(0) = 0. \end{cases} \quad (6)$$

Solution to (6) is known only in quadratures:

$$F_2'(t) = \omega_0 \sqrt{\rho_0} \sqrt{F_2(t) + l \ln F_2(t) - 1}.$$

If it is permissible to assume that the unknown function logarithm is small, then we obtain an approximate equality:

$F_2(t) \approx \frac{1}{2} \omega_0^2 \rho_0 t^2 + 1$, and border $x_3(t)$, thus, it will move at a square-law speed, while the concentration will decrease in inverse proportion to the time square:

$$\rho(x,t) \approx \frac{\rho_0}{1 + \frac{\omega_0^2 \rho_0 t^2}{2}}$$

Based on the obtained approximate equality, it is possible to approximately determine the moment when $x_3(t)$

"catch up" $x_1 = -l$: this will be an approximate equality $\frac{\omega_0^2 \rho_0 t_0^2}{2} \approx l$, that is, at time $t_0 \approx \sqrt{\frac{2l}{\omega_0^2 \rho_0}}$.

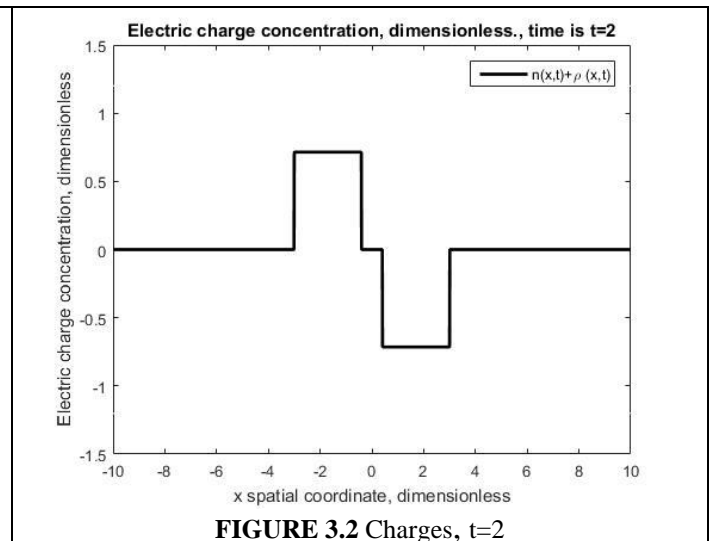
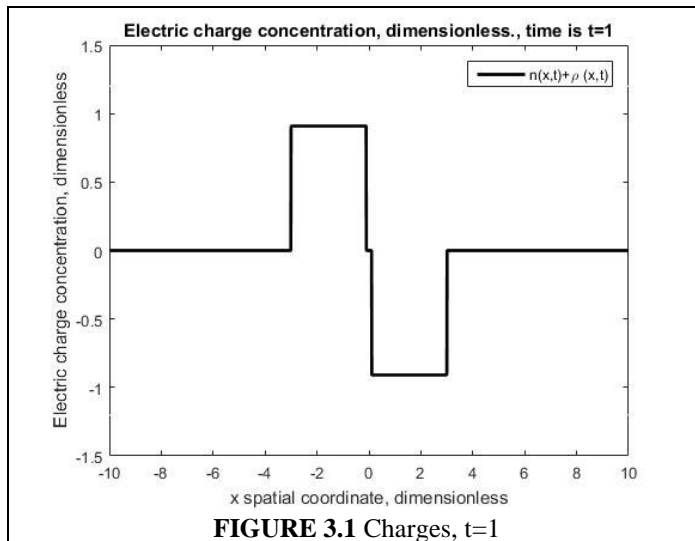
FURTHER PLASMA BEHAVIOR

In order not to overload the presentation, we will restrict ourselves to the situation qualitative development at further moments in time. After the border x_1 will be "bypassed", the border x_3 will continue to move at a constant speed $v_1 = \omega_0^2 \rho_0 t_0$, since no forces will act on it. At the same time the border x_1 will be exposed to an electric field E , and will move to "catch up" the border x_3 .

Note that the field will decrease due to the mutual superposition of the different signs charges regions and the charge resulting screening, and - quadratically.

So the border x_1 will accelerate, and the border x_3 will move at a constant speed. Accordingly, at some point in time, the boundaries will be at one point, and then the boundary x_1 "overtake" x_3 and the situation will repeat itself against the background of an ever decreasing electric field.

The images in Figure 3 give an idea of the situation development the from the view point the uncompensated charges relative position.



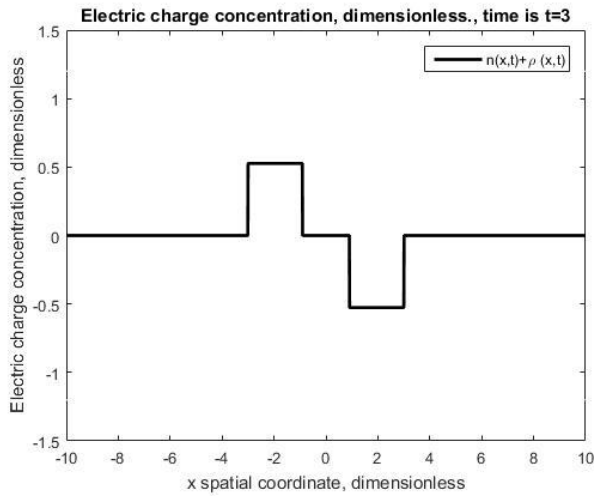


FIGURE 3.3 Charges, t=3

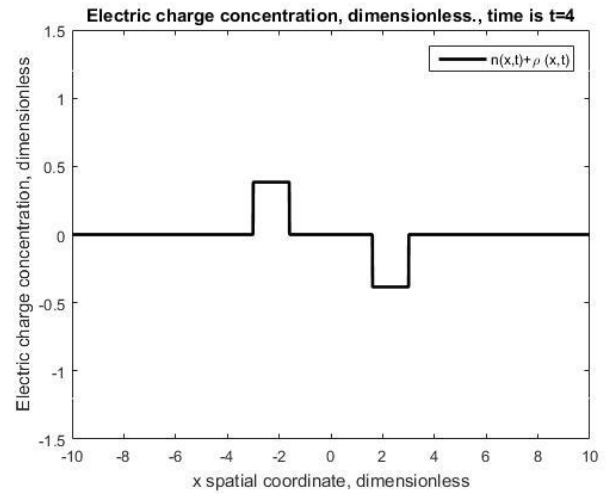


FIGURE 3.4 Charges, t=4

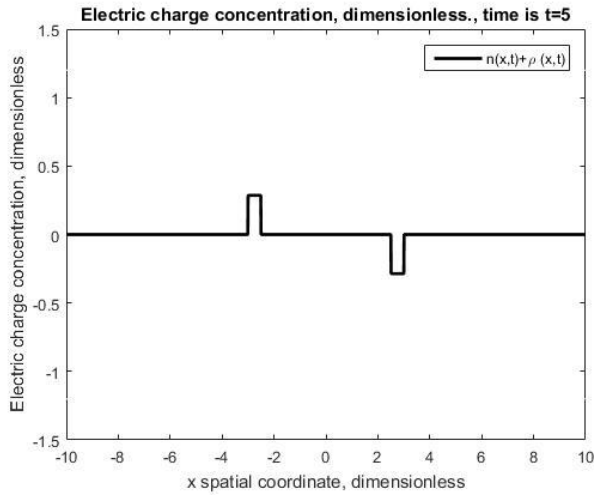


FIGURE 3.5 Charges, t=5

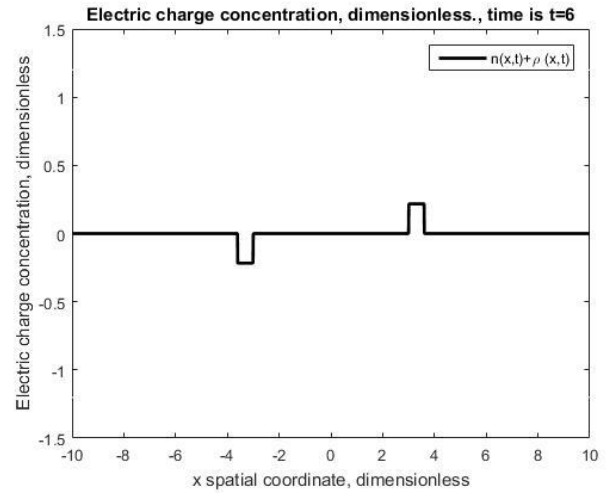


FIGURE 3.6 Charges, t=6

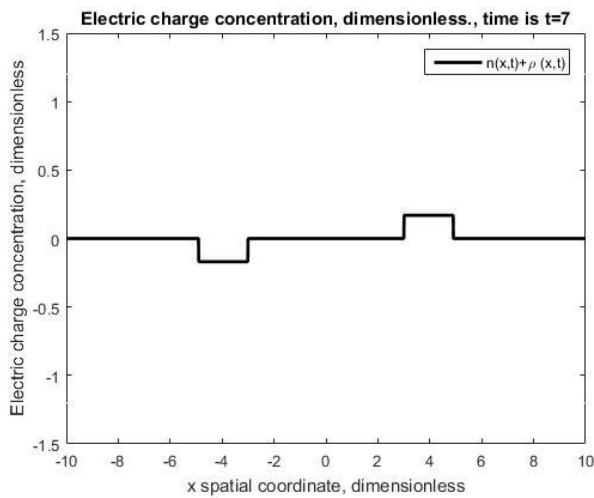


FIGURE 3.7 Charges, t=7

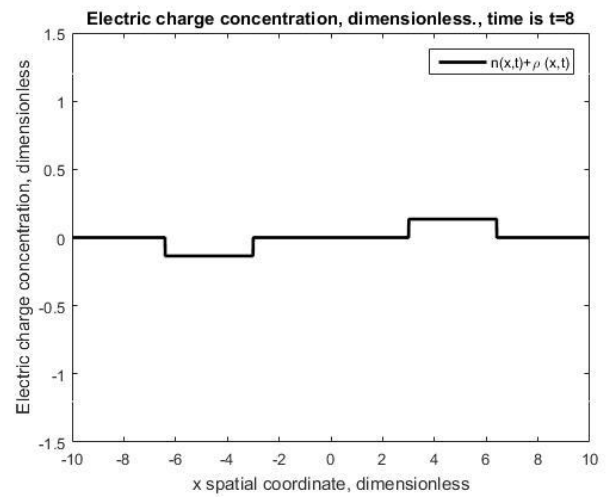


FIGURE 3.8 Charges, t=8

CONCLUSIONS

It follows from the above that, due to the chemical processes that cause charge separation, any colloidal system will have complex wave behavior due to the electric charges presence. Plasma waves caused by chemical processes are quite complex and require separate analysis.

On the other hand, the chemical process representation in a colloid as a set of waves provides a researcher with information about chemical processes in a colloid.

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