while the position of the cells can be found via

$$y(x,t) \;=\; \int_0^x P(x',t)x'dx'. \tag{7}$$

Underdamped case :— If the inertia effect is included, the Langevin equation can be written as

$$\frac{dV}{dt} \;=\; -\gamma V - f + \sqrt{2k_B\gamma T}\xi(t). \tag{8}$$

After some algebra, the average velocity is simplified to

$$V(t) = \left(\frac{1-e^{-\frac{\gamma t}{m}}}{\gamma}\right) f. \tag{9}$$

At steady state (in long time limit), the velocity (Eqs. (6) and (9)) approach $V = f/\gamma$. This result agrees with our previous works [9, 18].

The diffusion constant for the model system is given by $D = \frac{k_B T}{\gamma}$. This equation is valid when viscous friction is temperature dependent showing that the effect of temperature on the cells mobility is significant. When temperature increases, the viscous friction gets attenuated and as a result the diffusibility of the particle increases. Various experimental studies also showed that the viscosity of the medium tends to decrease as the temperature of the medium increases [1]. This is because increasing the temperature steps up the speed of the molecules, and this in turn creates a reduction in the interaction time between neighboring molecules. As a result, the intermolecular force between the molecules decreases and hence the magnitude of the viscous friction decreases. Next we explore the dependence of the ESR on number of RBCs that form rouleaux.

III. THE ERYTHROCYTE SEDIMENTATION RATE IN WESTERGREN PIPET

A. ESR as a function of the number of red blood cells that form rouleaux

In this section, the dependence of ESR on the number of erythrocytes that bind together in the sedimentation process is explored. As discussed before, the repulsive coulomb force between the RBCs keeps apart the cells from binding. As the result the viscous friction of the blood compels the cells to remain suspended in the solution. The presence of inflammatory disease results in elevated plasma fibrinogen. The fibrinogen forces the RBC to stick to each other to form aggregates of RBC called rouleaux. As the mass of the rouleaux increases, the weight of the cluster dominates the vicious friction and as a result the RBC starts to sediment. As depicted in the work [19], the sedimentation rate is linearly correlated with fibrinogen blood level.

As the fibrinogen blood level steps up, more RBCs tend to bind. Hence it is vital to explore the number of red blood cells that are involved in the sedimentation process at a given ESR. Exploiting Eqs. (6), (7) and (9), one can see that as the number of red blood cells (N) that form rouleaux steps up, the sedimentation rate increases (see Fig. 3). Figure 3 depicts the plot of ESR as a function of the number of RBCs (at 20 degree celsius) that forms rouleaux. As shown in the figure, the ESR increases as N steps up. The abnormal value for ESR is observed when $5X10^5$ or more RBCs form aggregate.

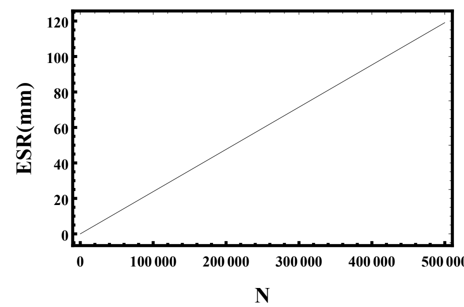

FIG. 3: (Color online) Erythrocyte sedimentation rate in one hour at 20 degree celsius. The ESR steps up as the number of red blood cells (N)that form rouleaux increases. The abnormal value for ESR is observed when $5X10^5$ or more RBCs form aggregate.

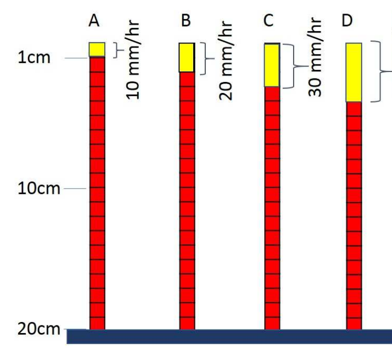

FIG. 4: (Color online) Schematic diagram that plotted based on the result shown in Fig. 3. The figure shows that $ESR = 10mm/hr$, $20mm/hr$, $30mm/hr$ and $40mm/hr$ when (the number of RBCs that form aggregate) $N = 4.1992X10^4$, $8.3984X10^4$, $N = 12.5976X10^4$ and $N = 16.7968X10^4$, respectively.

Figure 3 can be more illustrated by drawing a schematic diagram to show the dependence of ESR on N. Based on the result depicted in Figure 3, we redraw a schematic diagram in Fig. 4. The figure shows that $ESR = 10mm/hr$, $20mm/hr$, $30mm/hr$ and $40mm/hr$ when (the number of RBCs that form aggregate) $N = 4.1992X10^4$, $8.3984X10^4$, $N = 12.5976X10^4$ and $N = 16.7968X10^4$, respectively. One can note that each RBC undergoes a biased random walk since the external load (the weight of RBCs) compels the cells to sediment. The repulsive coulomb force interaction between