RESEARCH ARTICLE

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Soft Matter Physics and Global Pandemic Covid-19 an Indepth Insights

Anaswara Ramachandran[1], Rishi Dewangan[2], Sudhanshu Singh*[3]

[1] Deptt. of Integrated Physics, Central University of Tamilnadu, India; e-mail : minnutsr@gmail.com
[2,3] Amity University Rajasthan, Jaipur, India; *e-mail : singhs1183@gmail.com

ABSTRACT

World is going through a global pandemic COVID-19 and this situation can be explained through soft matter point of view. Covid-19 also known as Coronavirus have a complex form of nucleic acid and it has a strong lipid layer. A small analysis of soft matter properties of corona virus is done here. The virus is transmitting and mutating very fast and affected almost all sectors of world. The virus attack and virus transmission is explained and infection probability rate is also calculated. A detailed study about viral pandemics and tactics to prevent this using SMS (sanitizer, mask, social distancing) method is discussed and analyzed how this helps in decreasing virus transmission.

Key Words: COVID-19, Soft matter, Transmission, infection probability, SMS method.

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INTRODUCTION

Soft matter science and COVID 19 pandemic have a major a correlation. The viral interaction with body fluids for e.g. mucus and infectivity in the cell control system. COVID-19 is an enveloped virus they have a lipid bilayer shell and have a complex nucleic acid. It is global pandemic which have affected billions of people in the world and thousands of people are dying every day. [18-19] COVID-19 spreads when people are in close contact and inhales from the infected person (coughing, sneezing, and talking). The spread of the disease has been increased by the transmission through aerosol and aerodynamics.The relation of soft matter in COVID-19 is divided into two forms that are how the virus attacks the body and how it spreads. [6-22] COVID-19 is a disease caused by severe acute respiratory syndrome (SARS-CoV-2). They show the adhesive reaction like the bacteria while transmitting through mucus. Mucus is a slimy material that have important role in transmission of this pandemic and it is known as the super spreaders.

Physics based techniques have a major role in the field of structural biology. X-ray diffraction, Fourier transformation are the mechanisms used to understand the three dimensional formation and lattice structure of biological molecules. These techniques help also to identify the effects of this virus. [1-7] We are going to do a detail study on transmission of virus and how it attacks the immunity system and also going to discuss details about how it relates to soft matter. We are going to add some discussions and conclusions about this relation and going to do an analysis of COVID-19 transmission worldwide and how the transmission is increasing day to day. Study of virus interaction helps us to develop a suitable vaccine for this pandemic.

Corresponding Author : Sudhanshu Singh, Amity University Rajasthan, Jaipur, India; e-mail : singhs1183@gmail.com

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Infection probability and asymptotic character of this is also considered in our analysis. There is a lot that we don't know about this disease and we are struggling to fight against this and this report is a small discussion done on this matters [27]. This virus's soft matter science can be demonstrated by how the virus attacks the host's body and how infection spreads. This virus's soft matter science can be demonstrated by how the virus attacks the host's body and how infection spreads and there are great and vital roles of engineering nanomaterials in this work [28].

Soft Matter Physics and It's Properties

To give soft matter a more formal definition, we can say that they are the materials that are easily deformed. This includes everything from the ice cream and toothpaste, butter, paints on your bedroom wall, or even the blood and tissue in your body. In other words we can say that they are soft and squishy materials. It is wide branch in physics and have varieties of properties. Soft matter materials behave differently than solids and liquids and their properties remain in between solids and liquids. The intermingling of order and disorder leads to two important properties of all soft matter. First, soft materials exhibit a large response function. It means that a small change in conditions can dramatically alter the properties of the material. Second, under the right conditions, very complex soft matter structures will be formed. This is called self-assembly –an important factor in life process.

The important soft matter property is self-assembly it plays a major role in life processes. Viruses, collagen fibres, the intracellular cytoskeleton and DNA replication have all been found to rely on self-assembly and this help to identify the unknown factors about life processes. Other soft matter qualities are to control the structure and dynamics of living cells and they also drive motor proteins like the muscle protein myosin, which plays a big part in contracting muscle fibres. [2] Soft matter plays an inter disciplinary role in physics, chemistry, material science and in other various fields. There is various kind of soft matter among them many can be induced to flow under certain conditions. This is due to the lack of three dimensions, atomic long range order found in crystalline solids. The forces between the molecules are the balance of repulsive interaction of short distances and of attractive forces that acts over a large range of area.

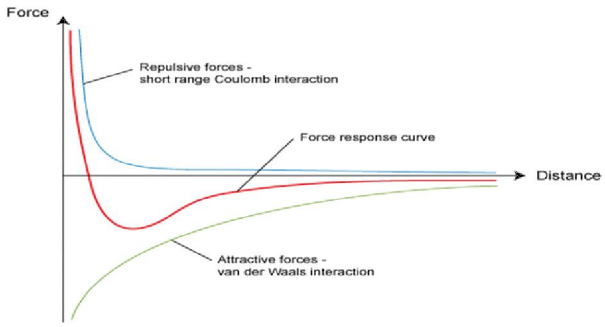


Figure 1:

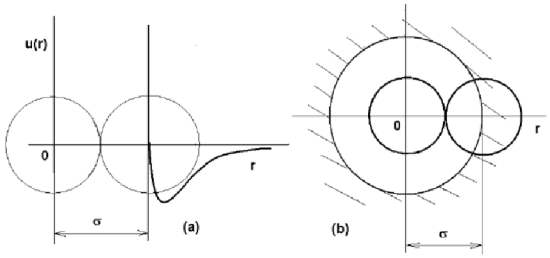


Figure 2:

The potential form that acts in soft matter is hard sphere potential that focuses mainly on the repulsive potential than the attractive forces because there are no attractive interactions in the hard sphere potential it does not describe the molecules well. Fig. (2) There should be attractive contribution in the potential and this is explained by the Lennard-Jones potential. This describes about the repulsive and attractive interactions.

[11] The major properties that distinguish soft matter from others is its structural organisation. The ordering is generally intermediate between the crystalline solids and liquids. Orientation order also comes under this. Another major feature of soft matter is the periodicity of the structure formed it have a range of 1-100 nm. It is also known as mesoscopic ordering. Many types of soft materials form structure of same symmetry. The difference between direct ordering and indirect ordering of molecules through super molecular aggregates is

one of the distinctions between different types of soft matter. Other important factor is the dynamics of the molecules. Macro molecules colloidal particles and micelles undergo Brownian motion. They all are subjected to random forces from the thermal motion of the surrounding molecules and they will follow a zig- zag motion of the colloidal particles which can also be described as the random walk. In short way we can say that self assemblence play a major role. Self-assembly is one of the key concepts in contemporary soft condensed matter. It is an umbrella term which encompasses the various modes of spontaneous organization of micrometer-and submicrometer-sized particles into ordered structures of various degrees of complexity, yet it often relies on remarkably simple interactions and mechanisms. Self-assembly is one of the key principles used by nature to construct living matter, where it frequently takes place in a hierarchical fashion.

COVID-19

Novel Corona virus disease has become a global pandemic.COVID-19 (coronary virus disease) is an infectious disease caused by extreme acute respiratory syndrome**.** Corona virus 2 (SARS-CoV-2).It was first identified in December 2019 in Wuhan, China, and has resulted in an on-going pandemic. There have been over 21 million cases registered, with over 765000 deaths. [22] More than 12 million people have regained their health. Most people affected by this virus experiences fever, throat pain and more over that they will experience respiratory problem. According to WHO the best way to prevent the disease and slow the transmission is by understanding how it causes and how it spreads. The virus spreads mainly due through the droplets of saliva or through mucus which discharges while coughing. Until now there is no vaccine or medicine to cure this disease. Recommended measures to prevent infection include frequent hand washing, keeping distance from infected persons, quaratine for those who have symptoms, covering coughs, and keeping unwashed hands away from the face. The use of cloth face coverings such as a scarf has been recommended by health officials in public settings to minimise the risk of transmissions, with some authorities requiring their use. Health officials also stated that medical-grade face masks, such as N95 masks, should be used only by healthcare workers, first responders, and those who directly care for infected individuals. [8-9]

When it comes to viruses, there is good reason to worry about its existence because we cannot tell them as a living organism and they are cellular organisms that replicate easily and kills the host. [26-27]Take Spanish flu for example, which killed up to 100 million people a century ago, and then more recently, HIV, which has led to around 32 million deaths to date. It is only a matter of time before another devastating pandemic, and though epidemiologists do not know what type of virus it will be, they do know that it will be different from anything witnessed before. [7-11]In the case of corona virus it is a RNA and it contains different composition than the known viruses and it's also getting mutated this makes difficulty in making vaccines. There are so many hidden secrets about this virus and we are going to study about this through the ideas of physics.

SELF-ASSEMBLY AND INFECTION PROBABILITY

Self-assembly is one of the important property of soft matter materials and it is known as the build block since it helps in building the functional structures from the nanoscopic scale to mesoscopic scale. We know that the Coronavirus have a lipid bilayer shell so it will have water loving (hydrophilic) head and water hating (hydrophobic) tail and they all are arranged in a self-assembled manner. [18] This part gives us the idea about spatio-temporal, changes in the biological signaling, transduction, healing and also about replication. Using this it's possible to integrate the four basic structures i.e. peptides, sugars, lipids and nucleo-bases. There are different scattering mechanisms used to understand the colloids and their self-assembly pattern and through this one can understand the intermolecular and inter-particle interactions.[3-5] Crystallography, electron microscopy and mass spectrometer helps to find out the protein measurement. **In here we are going to provide data's that have been collected from the WHO and we are going to find out the infection probability from the given data. Infection

rate of corona virus is increasing day by day and it has reached its peak. Using Wells-Riley equation we can get an idea of infection rate, this gives an assessment of infection risk of airborne transmissible diseases.[25] The increasing rate of COVID through contact proves that it is transmitting through air. This model tells about the ventilation rate as the factor of infection rate. Natural ventilation and artificial ventilation will reduce the risk but we cannot control it until we find the proper vaccine for the disease. While comparing the graphs we can find out an exponential increase in the number of patients from the month of January to October 2020. Data to date shows that 80% of infections are mild and the other 15% have severe problems due to the infection and the last 5% have critical infections and they need the help of ventilation. Wells-Riley equation states infection probability (P_i)

$$P_i = C/S = 1-\exp(-Iqpt/Q)$$

Where,

- C=probability of infection
- S=susceptible number
- I=number of infectors
- p=pulmonary ventilators
- q=quanta generation
- t=exposure time interval
- Q=room ventilation rate with clean air

We are calculating this through the data's given by WHO website. In here we are calculating the infection probability of India and USA and comparing it with world. While calculating we got the result that infection probability for India is 0.6 (60%) and in USA is 0.75 (75%). And from the graph given below we can understand that they are showing an exponential rise in infection. (from figure 3 and 4)

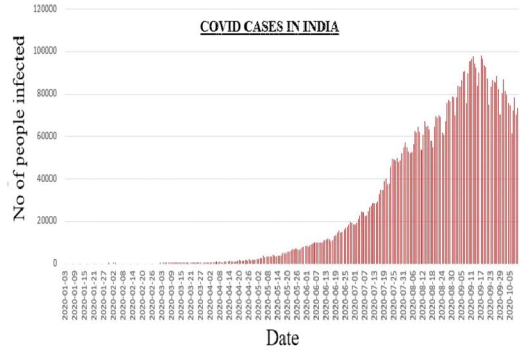
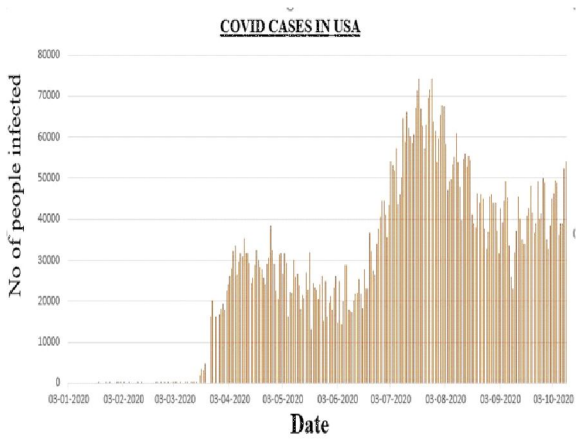
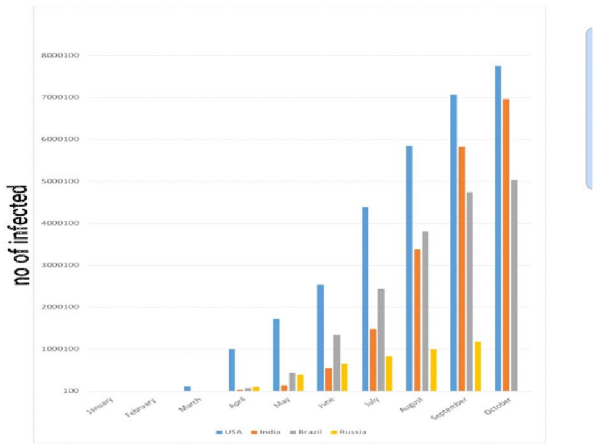


Figure 3:





** Comparison data of infected peoples in the major infected countries from the month of January till October 2020.

Figure 4:

We can say that the 80% of the people testing for COVID positive are asymptomatic in nature. From the calculation done by Hui Dai and Bin Zhao they obtained the q value as 14 to 48 h^{-1} (quanta generation rate).

TRANSMISSION

We can say that the corona viruses are spreading more through air and through personal contact so in conclusion COVID 19 is an airborne disease [15-16]. They are so microscopic in size and have RNA strand and people around the world is working hard to find cure for this. We can understand the air transmission from the figure (5) given below.

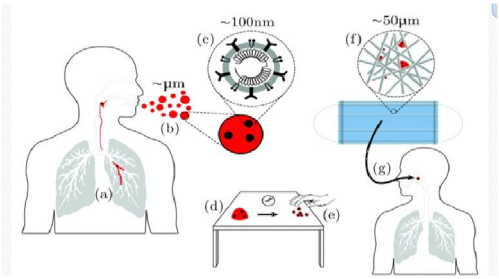


Figure 5:

In this diagram (a) shows a person infected by virus. (b) Virus transmitted out through mucus by cough or by sneezing. (c) Corona virus RNA strand with a double lipid layer. (d)Droplets falling on surface get dried. (e) adsorbed virus particles. (f) Droplet gets attached to the face mask. (g) Air flows through porous.[22]

While connecting this we can say that mucus is a squishy and soft material which belongs to the category of soft matter. Mucus is a gel which has the property of both solid and liquid. They act as a guard for lungs but in here it is carrying the enemy virus to the lungs. They have heavy glycosylated proteins in them and also have soft matter properties. 1% of 5 μm will contain virions. A small strand of virus will diffuse or otherwise it gets fully gets merged into the surface of the droplets. We can explain this through the interactive forces acting between them. We can say that in the case of corona virus mucus and water droplets are acting as a traitor which is helping virus to spread faster. [17-18]

There are various level of forces acting in them the most important ones are the electrostatic force and the Van der Waal's force. [23-24] After the droplets enter the body which contain the virus then they attacks the cells and even the genes they get replicate and damage the cell. We can say in detail that the drying dilute droplets have Newtonian force in them and they help the virus to spread. In here we can also explain the capillary forces and how they interact with the surfaces. How they act and how they transfer and also tells about origin of microorganisms. [21-22]

Precaution and Prevention Mechanism

The best method of protection is taking initial protection from virus spread and taking enough social distancing. Rehydration of a substantially desiccated BLSV (big liver and spleen disease virus) composite particle and its mechanism on a saliva or mucus will act on the epithelial surface. This can be explained through complexsoft matter science and biological physics.[7-8] Now we will explain each protective measure:

Mask

Through surveys we have find out that wearing a mask is a method of protection against this global pandemic. Mask is indeed a protection but how much it helps in prevention can be explained through various studies. One among them is the study of Schlieren imaging, make it clear that wearing different face coverings will significantly reduce the amount of air that comes out of a person's mouth or nose while they are breathing or coughingand it also helps in prevention of entering microorganisms through mouth and nose [2].The Centers for Disease Control and Prevention (CDC) in the United States recommends wearing N95 masks to protect against SARS-CoV-2. The CDC's National Institute for Occupational Safety and Health has a standard for certifying N95 filter fabrics. One of the important issue arise during this was the reuse of masks after washing and this can be explained by the soft matter physics about fabrics and how they react with heat and humid. From fig (6) we can understand that the number of persons infected will get rise if we are not wearing mask because without mask the transmission rate increases.

Sanitizer

The other method of prevention against this pandemic is the use of Sanitizer. Sanitizer is made of alcohols, various chemicals. Studies have found that the use of soaps have helped in destroying bacteria and viruses [H1N1 spreading has been stopped by the use of soap in a certain level]. [10]The CDC recommends that soap be used to sanitise hands against bacterial pathogens based on findings from studies.Washing with soap helps

to remove dirt, bacteria [pathogens], oil and greasein the body. Previous publications on the antiviral activity of commercial surfactant products are mentioned in a recent preprint, but these and other studies report efficacy measurements with lipid membrane [9-19]

Social-distancing

This is an unknown virus to the human kind therefore we have to take each step very carefully. Now we know that this virus is spreading through contact so we have to maintain social distancing. That's why the world has taken an initiative of lock down and quarantine mechanisms. The infection period is 11 to 12 days and the exposure period is for 5 days so there is a total quarantine period of 14 days. Some of the patients will not show any symptoms of disease there for we need to avoid unnecessary contact.

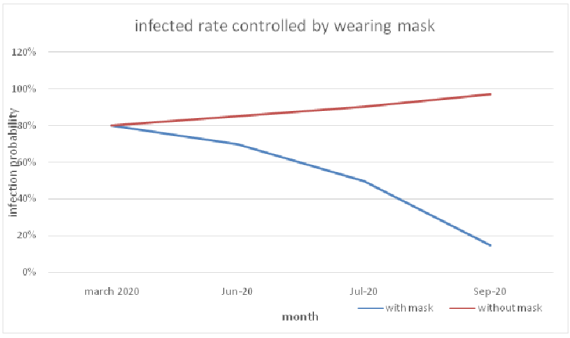


Figure 6:

Discussion and Conclusion

We mainly focused on the relation of physics in global pandemic and we tried to get an overall idea about the subject. All data are collected from recent articles and publications and we tried to add our own views into it. Soft matter physics is a wide branch, here I have given some details of this branch and also explained how this can be related to COVID-19. Here some of the data was collected from who and some from Indian medical Association. We have to understand the forces acting in here and have to be aware about the prevention mechanisms.

Before offering some concluding are marks, we should say that this is only a survey report. Corona virus is not an object, we cannot see it or touch it. We are finding and discovering new medicines and vaccines for this. We can say that soft matter plays a major role in it. Let's hope and prepare for this viral pandemic.

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Reference

[1] C. V. Seastone, J. Gen. Physiol., 1938

[2] S. Y S. S. Olmsted, J. L. Padgett, A. I. Yudin, K. J. Whaley, T. R. Moench and R. A. Cone, Biophys. J., 2001.

[3] ang, G. W. Lee, C.-M. Chen, C.-C. Wu and K.-P. Yu, J. Aerosol Med., 2007,

[4] J. H. STRAUSS and E. G. STRAUSS, Viruses and Human Disease (Second Edition), Academic Press, London, Second Edition edn, 2008.

[5] N. Martín-González, S. M. G. Darvas, A. Durana, G. A. Marti, D. M. A. Guérin and P. J. de Pablo, J. Phys.: Condens. Matter, 2018, 30, 104001. 69 J. Shaman and M. Kohn, Proc. Natl. Acad. Sci. (USA), 2009

[6] 13 S. K. Lai, Y.-Y. Wang, K. Hida, R. Cone and J. Hanes, Proc. Natl. Acad. Sci. (USA), 2010

[7] Sato and H. Kiyono, Curr. Op. Virology, 2012,

[8] G. U. Lopez, C. P. Gerba, A. H. Tamimi, M. Kitajima, S. L. Maxwell and J. B. Rose, Appl. Environ. Microbiol., 2013

[9] A. Macierzanka, A. R. Mackie, B. H. Bajka, N. M. Rigby, F. Nau and D. Dupont, PLoS One, 2014

[10] L. Bourouiba, E. Dehandschoewercker and J. Bush, J. Fluid Mech., 2014

[11] A. Lindner, J. E. Fiscina and C. Wagner, EPL (Europhysics Letters), 2015

[12] B. E. Scharfman, A. H. Techet, J. W. M. Bush and L. Bourouiba, Exp. Fluids, 2016

[13] M. Haw, Middle World, Palgrave Macmillan US, 2016.

[14] J. A. Otter, C. Donskey, S. Yezli, S. Douthwaite, S. D. Gold- enberg and D. J. Weber, J. Hosp. Infect., 2016

[15] R. J. Fischer, T. Bushmaker, S. Judson and V. J. Munster, J. Infect. Dis., 2016,

[16] E. P. Vejerano and L. C. Marr, J. Royal Soc. Interface, 2018,

[17] J. S. Kutter, M. I. Spronken, P. L. Fraaij, R. A. Fouchier and S. Herfst, Curr. Opin. Virol., 2018

[18] J. Zhou, J. Wei, K.-T. Choy, S. F. Sia, D. K. Rowlands, D. Yu, C.-Y. Wu, W. G. Lindsley, B. J. Cowling, J. McDevitt, M. Peiris, Y. Li and H.-L. Yen, Proc. Natl. Acad. Sci. (USA), 2018.

[19] K.A.Kormuth,K.Lin,I.Prussin,AaronJ, E.P.Vejerano, A.J. Tiwari, S. S. Cox, M. M. Myerburg, S. S. Lakdawala and L. C. Marr, J. Infect. Dis., 2018,

[20] R. Bansil and B. S. Turner, Adv. Drug Deliv. Rev., 2018

[21] P. Zhao, P.-T. Chan, Y. Gao, H.-W. Lai, T. Zhang and Y. Li, Build. Environ., 2019,

[22] Soft matter science and the COVID-19 pandemic Wilson C K Poon," a Aidan T Brown,a Susana O. L. Direito, a Daniel J M Hodgson,a Lucas Le Nagard,a Alex Lips, a Cait E MacPhee,a Davide Marenduzzo,a John R Royer,a Andreia F Silva,a Job H JThijssen,a and Simon Titmus,2020

[23] R.Rabadan, Understanding Coronavirus, Cambridge University Press, 2020.

[24] Heymann DL, Shindo N, et al. (WHO Scientific and Technical Advisory ,Group for Infectious Hazards) (February 2020)

[25] N.van Doremalen, T.Bushmaker, D.Morris, M. Holbrook, A. Gamble, B. Williamson, A. Tamin, J. Harcourt, N. Thorn- burg, S. Gerber, J. Lloyd-Smith, E. de Wit and V. Munster, New Engl. J. Med., 2020,.

[26] T.-C. Hsiao, H.-C. Chuang, S. M. Grifûth, S.-J. Chen and L.- H. Young, Aerosol Air Qual. Res., 2020,

[27] P. S. Raux, A. Troger, P. Jop and A. Sauret, Phys. Rev. Fluids, 2020.

[28] Dey, S., et al. (2016). "The structural properties of BaTiO3: TiO2: PMMA composite films at room temperature". AIP Conference Proceedings, 1728, 1.