Plant Archives Vol. 20, Supplement 2, 2020 pp. 3507-3511 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

RHEOLOGICAL PROPERTIES OF HOMEOPATHIC PREPARATION OF ANIMAL AND PLANT BASED SYNOVAIL MIMIC FLUID WITH MWCNT AND ALUMUNA NANOPARTICLES

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Abstract

In present study rheological properties of synovial mimic fluids are experimentally evaluated. The samples are tested at varing shear rate. Samples are prepared with animal (albumin) and plant (*Zea mays*) based fluid with MWCNTs and alumina nanoparticles in homeopathic preparation. Samples show non-Newtonion behvaior, which is align to synovial fluid nature. Animal based synovial mimic fluid show shear thinning bheaviour, whereas shear thickening behavour observed with plant based fluid. This is a preliminary study on synovial minimc fluid with homeopathic preparation to provides base for further exploration.
Keywords: Synovail fluid, Rheology, Plant fluid, Osteoarthritis, MWCNTS, Alumina.

Introduction

Arthritis is the chronic disease, which generally appears in the aging population. This disease widely prevails in form of osteoarthritis (OA) and rheumatism (RA). RA is disease of soft connective tissues and caused by disorder in the immune system. OA cause degeneration of joint tissues, resulted in pain, stiffness and impaired physical function. Although, there is no standard definition for OA, it can be defined structurally or symptomatically (Rajgurav *et al.,* 2017). Lubrication properties of synovial fluid (SF) significantly detoriates in degenerative disease (OA) (Bhuanantanondh *et al.,* 2014; Koley *et al.,* 2015). The lubrication properties largely depandes on the rheological properties of the fluid (Kotia *et al.,* 2019; Kotia *et al.*, 2018a-b); Kotia *et al.,* 2015; Kotia *et al.*, 2017a-c). The presence of nanoparticles additives made significant variation in rheological properties of base fluid (Raghvendra *et al.*, 2017; Kotia *et al.,* 2016 a-d).

In allopathic medication system, conventional management of OA disease includes administration of NSAID, DMARDs like methotriscate and anti-tumer necrosis factor α-monoclonal antibody. Gastric, ulcer, bleeding and perforat are the most common known adverse reaction associates with excessive consumption of NSAIDs. The homeopathic system of medicine improves the general well being, with reducing pain and disability. It also limits the need of analgoric and DMARDs in RA (Fisher and Scott. 2001). There was significant effect on osteoarthritis by usage of homeopathic complexes, individual homeopathy yet to be tested. By this testing it shows placebo is inferior to homeopathy treatment (Koley *et al.,* 2015).

Patient quality of life is increased by reducing pain and stiffness of joints with usage of homeopathy medicine (Motiwala *et al.,* 2016). Homoeopathic limits the need of analgesics and DMARDs in RA (Kundu *et al.,* 2014). Homeopathic consultation patients are active and relatively stable than homeopathic intervention. There are two primary out comes one 20% improvement based on outcome measures in rheumatology and another is improvement in patient health (Brien *et al.,* 2011; Fries *et al.,* 1980; Felson *et al.,* 1995).

Lubrication properties of SF provies one way monitor the improvemnent. In general lubricants are used for friction reduction between two sliding/rotational surfaces. It also used for cooling, sealing and cleaning purposes. Base oil are broadly classified as synthetic, mineral and biological oil (Mortier *et al.*, 2010, Mia *et al.,* 2018, Gupta *et al.,* 2019). Researchers used nanoparticles to modify properties of base fluid (Bhardwai *et al.,* 2014; Busari *et al.,* 2017; Chauhan and Mishra, 2018; Gulati *et al.,* 2013; Gupta *et al.,* 2013; Kaur and Jaryal, 2018; Kaur *et al.,* 2014; Kaur *et al.,* 2015). The plant physiology is also significanty varied with their bio-chemical syetem (Kumar *et al.,* 2019; Kumar and Padmanabh 2018). Plant growth is one of the significant factor hamper (Kumar and Padmanabh, 2018b; Kumar *et al.,* 2019). This modifications plant and animal extract fluid motivate researchers identity further applications in biofluids (Devi *et al.*, 2014; Duran *et al.* 2015; Jha *et al.*, 2019; Kumar *et al.*, 2017; Mehta *et al.,* 2016). Prasher *et al.,* (2018) evaluated antimicrobial therapeutics with silver nanoparticles. Neha *et al.,* (2018) investigate antimicrobial properties of mateallic nanoparticles. Similar studies has been attempted by various researchers (Nagpal *et al.*, *2015;* Patel and Duran, 2017; Mehta *et al.,* 2016; Sachdeva *et al.,* 2016; Radhika *et al.,* 2014, Sharma 2016; Yadav *et al.,* 2011).

In present study, animal and plant based synovial fluid's rheological properties are experimentally evaluated. The samples are prepared in homeopathic preparation with MWCNTs and alumina nanoparticles. Viscosity of samples is measured in varing shear rate.

Materials and Methods

In the present study synovial fluid (SF) mimic fluid is taken from plant (*Zea mays*, Kumar and Padmanabh, 2018a) and animal (albumin, Kaur and Singh, 2015). Homeopathic preparation is made with ethanol and nanoparticle. MWCNTs (Sharma *et al.,* 2016; Ahmadi *et al.,* 2019; Annu *et al.*, 2014) and alumina nanoparticles are used in this study. Table 1 shows the symbiolic representation of the samples.

Table 1: Symbiolic representation of sample

Sample	Symbol
Synovial fluid animal plain	SF_A_P
Synovial fluid animal MWCNTS	SF_A_MWCNTS
Synovial fluid animal alumina	SF_A_Al
Synovial fluid plant plain	SF_P_P
Synovial fluid plant MWCNTS	SF_P_MWCNTS
Synovial fluid plant alumina	SF_P_Al

Figure 1 shows the image of SF_A_P, SF_A_MWCNTS and SF_A_Al samples. The similar samples are prepared from plant source. Figure 2 shows the FESEM micrograph of alumina nanoparticles. It can be observed that nanoparticles have spherical morphology, which contributes in ball bearing effce (Kotia *et al*., 2017; Kotia *et al*., 2018; Kotia *et al*., 2019). Figure 3 shows the FESEM micrographs for MWCNT nanoparticles. It can be observed that MWCNTs have tubular morphology.

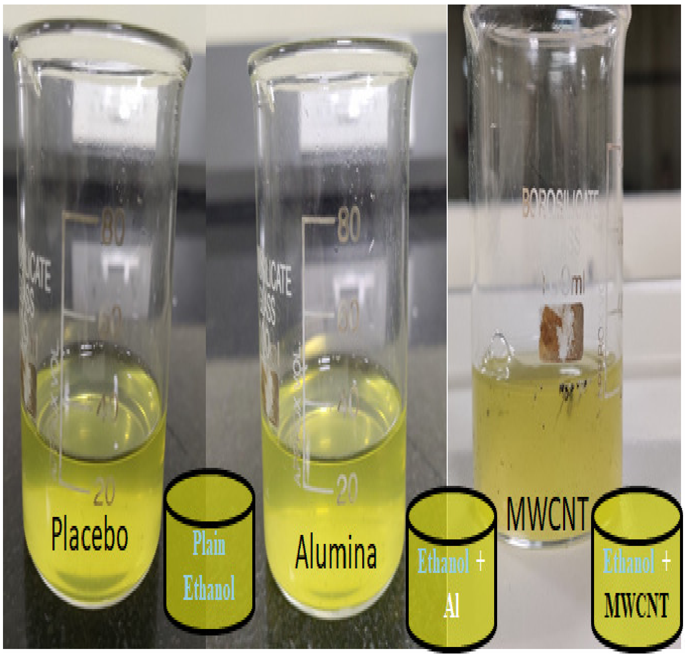

Fig. 1: Sample images

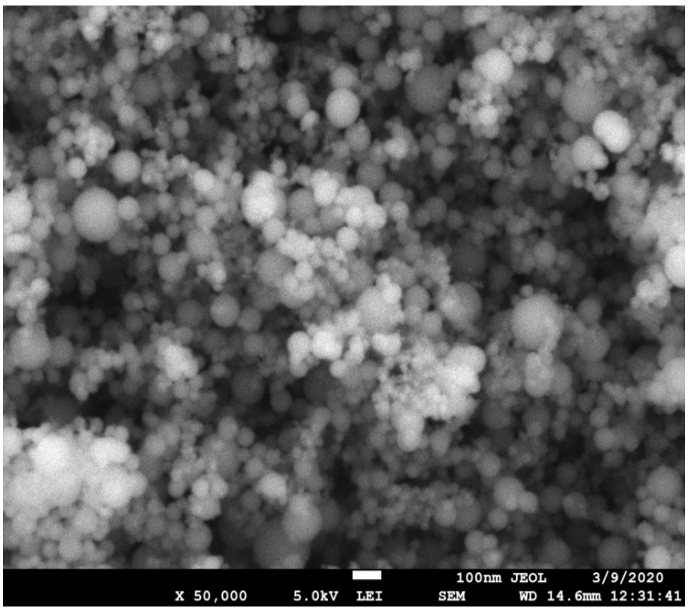

Fig. 2 : FESEM micrograph of alumina nanoparticles

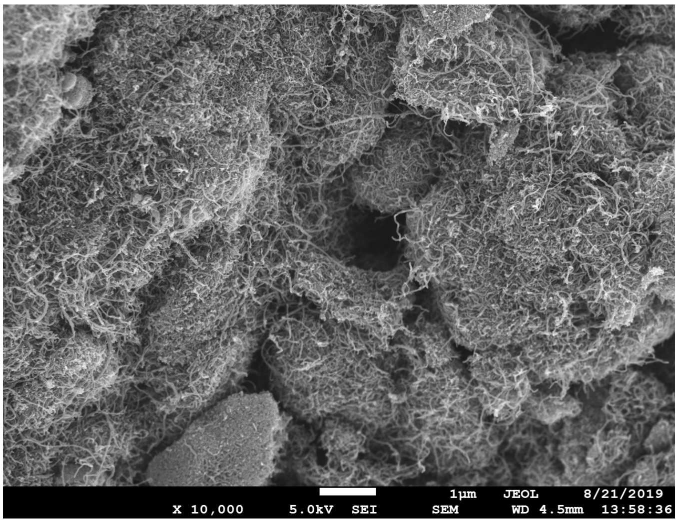

Fig. 3 : FESEM micrograph of MWCNT nanoparticles

Results and Discussion

Shear viscosity of samples is measured in a rheometer. Initially each sample is subjected to a least shear rate (0.01 s^{-1}). Subsequently shear rate increase to each 0.01 s^{-1}, to observe moment of bob. The shear rate at which sample show first moment is identified its zero shear rate viscosity. It can be observed that SF_P_P sample have least zero shear viscosity, followed by SF_P_MWCNTS sample. There is significant change in zero shear viscosity with dispersion of alumina nanoparticles.

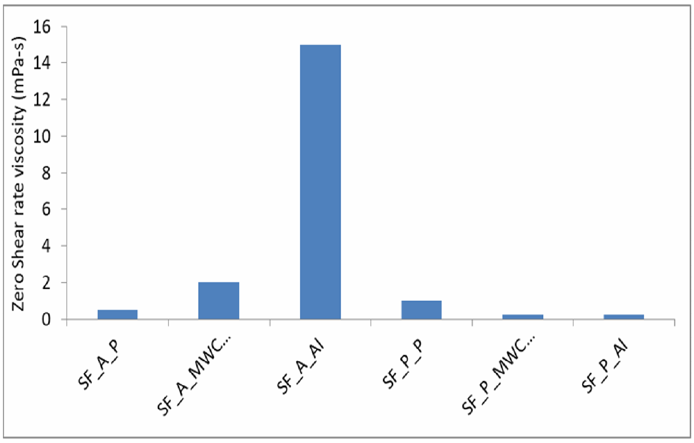

Fig. 4: Zero shear viscosity

Figure 5 shows the variation in viscosity with shear rate for SF_A_P. It can be observed that dynamic viscosity gradually decrease with increasing shear rate. This decrease in viscosity is an indicator of shear thinning behavior of synovial mimic fluid, which replicates nature of healthy synovial fluid. Non-Newtonian behavior with shear thinning of SF, facilities the optimum lubrication in low to high load and shear rate condition. It can be observed that there is negligible variation in reading in four repetitive measurements. Relaxation time of 10 minutes is used avoid time dependency of fluid response. The variation follows a logarithmic curve with following relation:

$$\mu = 1709.8\gamma^{-0.251} \quad ...(1)$$

where, μ and γ are dynamic viscosity and shear rate respectively.

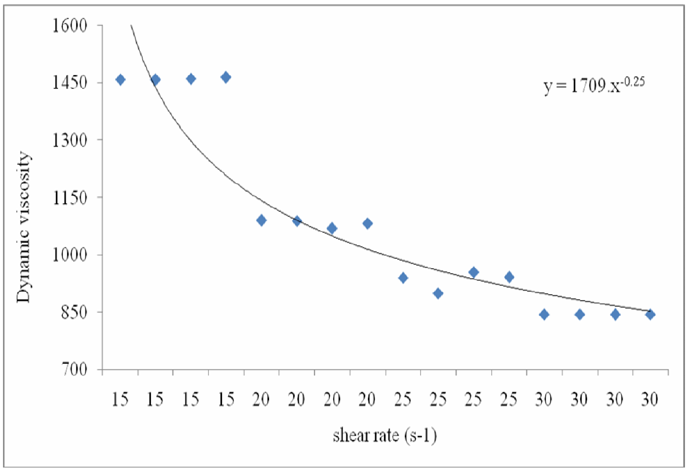

Fig. 5: Viscosity variation with shear rate for SF_A_P

Figure 6 shows the variation in viscosity with shear rate for SF_P_P. It can be obsrevd that there was increase in viscosity with shear rate. This indicates shear-thickning behavior.

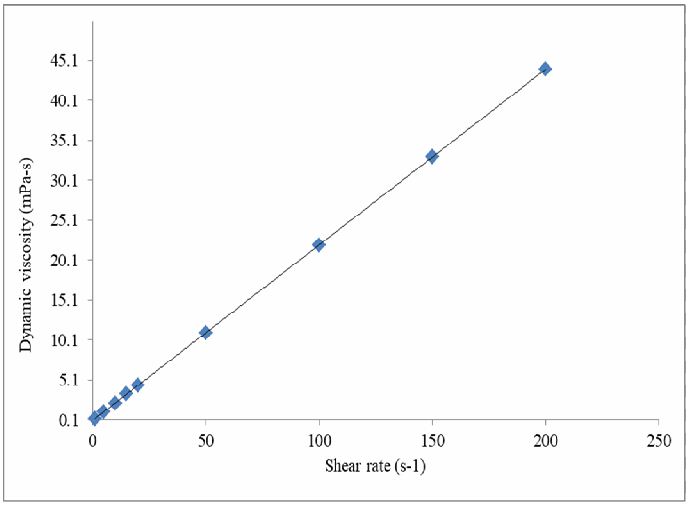

Fig. 6: Viscosity variation with shear rate for SF_P_P

Figure 7 shows the variation in viscosity with shear rate for SF_A_MWCNT sample. It can be observed that there was higher zero shear viscosity compared to SF_A_P. The trend of Non-Newtonian behavior with shear thinning is observed as similar to previous case. There was very minor variation in viscosity at higher shear rate and it follows logarithmic variation, govern by following correlation:

$$\mu = 1810.2\gamma^{-0.638} \qquad ...(2)$$

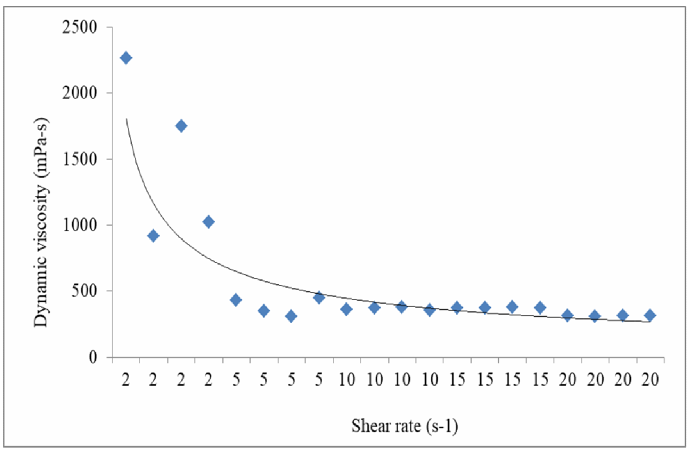

Fig. 7: Viscosity variation with shear rate for SF_A_MWCNT

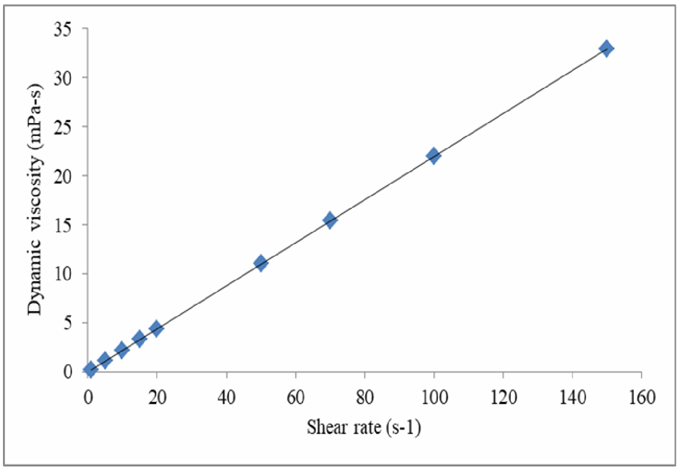

Fig. 8: Viscosity variation with shear rate for SF_P_MWCNT sample

Figure 8 shows the variation of viscosity with shear rate for SF_P_MWCNT sample. It has shear thickening behavior. The graduation incement in viscosity is very property of synovial fluid, that provies load bearing capacity. Figure 9 shows the variation in viscosity with shear rate for SF_A_Al. It can be observed there is significant improvement in zero shear viscosity with alumina nanoparticles. The trend follows logarithmic variation and its correlation expressed as:

$$\mu = 4462.3.2\gamma^{-0.965} \qquad ...(3)$$

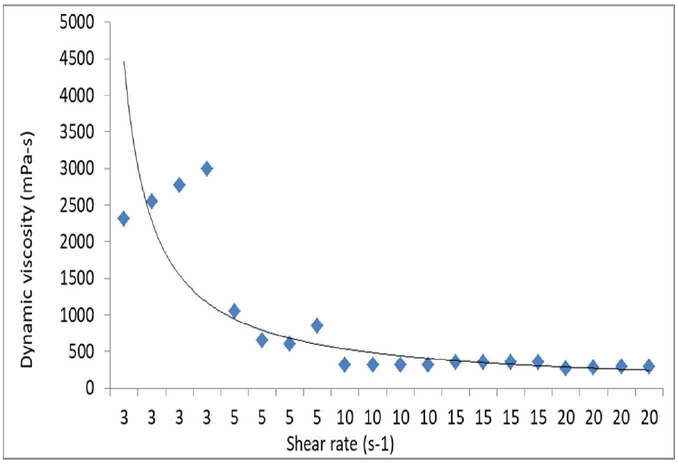

Fig. 9: Viscosity variation with shear rate for SF_A_Al

Figure 10 shows the variation in viscosity with shear rate for SF_P_Al. It can be observed fluid show an paculier behavior. Initiall there were increase in viscosity with shear rate, however there where significant incement after 20 s-1 shear. Also, there were gradual decrement in viscosity with shear rate with further increase in shear rate.

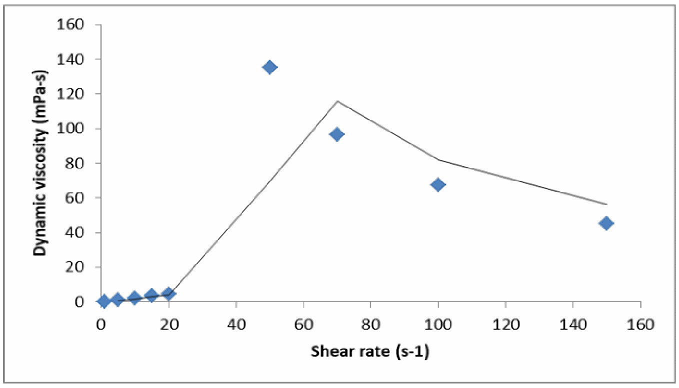

Fig. 10: Viscosity variation with shear rate for SF_P_Al

Conclusion

In present study experimental rheological properties of synovial mimic fluids are evaluated. The samples are tested at varing shear rate. Albumin and plant based fluid are used as synovial mimic fluid. The samples are tested in homeopathic preparation using MWCNTs and alumina nanoparticles. Samples displayed non-Newtonion behavior, which align to synovial fluid. The fluid shows significant variation in flow properties with the nanoparticles.

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