RHEOLOGICAL PROPERTIES OF HOMEOPATHIC PREPARATION OF ANIMAL AND PLANT BASED SYNOVIAL MIMIC FLUID WITH MWCNT AND ALUMINA NANOPARTICLES

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Abstract

In present study rheological properties of synovial mimic fluids are experimentally evaluated. The samples are tested at varying 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-Newtonian behavior, which is align to synovial fluid nature. Animal based synovial mimic fluid show shear thinning behaviour, whereas shear thickening behaviour observed with plant based fluid. This is a preliminary study on synovial miminc fluid with homeopathic preparation to provides base for further exploration.

Keywords: Synovial 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 deteriorates in degenerative disease (OA) (Bhuananthanondh et al., 2014; Koley et al., 2015). The lubrication properties largely depends 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 methotresiticate and anti-tumor 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 analgotic 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 improvement. 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 significantly varied with their bio-chemical syetem (Kumar et al., 2019; Kumar and Padmanab 2018). Plant growth is one of the significant factor hamper (Kumar and Padmanab, 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; Patil 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 varying shear rate.

Materials and Methods

In the present study synovial fluid (SF) mimic fluid is taken from plant (Zea mays, Kumar and Padmanab, 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: Symbiotic representation of sample

<table>
<thead>
<tr>
<th>Sample</th>
<th>Symbol</th>
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<tbody>
<tr>
<td>Synovial fluid animal plain</td>
<td>SF_A_P</td>
</tr>
<tr>
<td>Synovial fluid animal MWCNTS</td>
<td>SF_A_MWCNTS</td>
</tr>
<tr>
<td>Synovial fluid animal alumina</td>
<td>SF_A_Al</td>
</tr>
<tr>
<td>Synovial fluid plant plain</td>
<td>SF_P_P</td>
</tr>
<tr>
<td>Synovial fluid plant MWCNTS</td>
<td>SF_P_MWCNTS</td>
</tr>
<tr>
<td>Synovial fluid plant alumina</td>
<td>SF_P_Al</td>
</tr>
</tbody>
</table>

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 efficie (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](image1)

![Fig. 2: FESEM micrograph of alumina nanoparticles](image2)

### 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. 3: FESEM micrograph of MWCNT nanoparticles](image3)

![Fig. 4: Zero shear viscosity](image4)

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 where, \( \mu \) and \( \gamma \) are dynamic viscosity and shear rate respectively.

\[
\mu = 1709.8\gamma^{-0.251} \tag{1}
\]
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 observed that there was increase in viscosity with shear rate. This indicates shear-thickening 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, governed by following correlation:

\[ \mu = 1810.2 \gamma^{-0.638} \]  

...(2)

Fig. 7: Viscosity variation with shear rate for SF_A_MWCNT

Figure 8 shows the variation of viscosity with shear rate for SF_P_MWCNT sample. It has shear thickening behavior. The graduation increment 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:

\[ \mu = 4462.3 \gamma^{-0.965} \]  

...(3)

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

Fig. 9: Viscosity variation with shear rate for SF_A_Al

Figure 10 shows the variation in viscosity with shear rate for SF_P_A1. It can be observed fluid show an peculiar behavior. Initially there were increase in viscosity with shear rate, however there where significant increment 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_A1
Rheological properties of homeopathic preparation of animal and plant based synovial mimic fluid with MWCNT and alumina nanoparticles

Conclusion

In present study experimental rheological properties of synovial mimic fluids are evaluated. The samples are tested at varying 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-Newtonian behavior, which align to synovial fluid. The fluid shows significant variation in flow properties with the nanoparticles.

References


