Rotating Magnetic Nanoparticles to Measure Microviscosity in Gels

Koo, Wei De (School: National Junior College)

Emerging therapeutic techniques employ the use of drug-loaded gels, providing targeted treatment critical to prevent indiscriminate damage by drugs. It is essential to measure drug release rate to control it for greater treatment efficacy. However, directly measuring drug release is usually too time-consuming as gels are designed for slow release. Hence, drug release is indirectly measured by measuring microviscosity, which it is inversely related to. Yet, prominent light techniques to measure microviscosity are unsuitable due to non-transparent biodegradable gels used. Here, a novel system for microviscosity measurement is developed using rotating magnetic nanoparticles (MNPs). This technique hinges on measuring phase lag between an applied rotating magnetic field and the rotation of MNPs. When MNPs are in a rotating field generated by orthogonal coils, a phase lag arises from torque impedance due to gel viscosity which is measured by sensing coils to calculate microviscosity. This compact, sensitive and low cost magnetic impedance spectroscopy system is accurate with deviations below 5% and is highly efficient; measurements take only 10 minutes and labelling with MNPs is done just once even for multiple samplings. Microviscosity results on polyvinyl alcohol (PVA) cyrogels were supported by past works, further verifying the system's accuracy. The system then investigated microviscosity of novel hybrid gel, polyvinyl alcohol – calcium pectin (PVA-CaP) which has strength thrice that of PVA. It revealed that both gels have the same microviscosity under room conditions and PVA-CaP has lower microviscosity at higher temperatures. This finding is crucial for developing and applying gels with higher efficacy where increase in gel strength does not compromise drug release.

Awards Won: