Enhancement of Magnetorheological Fluids for Prosthetic Knee Applications

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In developing knee prosthetics, actively tuning the stiffness of the knee is crucial to facilitate natural movement and decrease fatigue for the amputee. Latest devices exploit the highly tunable on-off state of magnetorheological fluids (MRFs), given their ability to rapidly change from liquid to a semi-solid state under the influence of applied magnetic fields. Nonetheless, current technologies face challenges in a) flexibility, b) support for weight/activity and c) device lifespan, due to limitations of the MRF used. This investigation tackles these challenges by enhancing the corresponding MRF properties: a) reducing off-state viscosity, b) increasing on-state yield stress and c) improving stability against sedimentation. Owing to high oleic acid content, MRFs utilising a novel base fluid of safflower oil displayed superior on-state yield stress as well as improved stability against sedimentation compared to conventional silicone oil. Addition of FeCo submicron particles (SMP) strengthened Fe columnar structures formed on-state, increasing the on-state yield stress. This also improved the suspension stability and bypassed the traditional problem of increased off-state viscosity due to greater solid loading. Coating the FeCo SMP with stearic acid largely reduced interparticle aggregation, further improving the on-state yield stress attainable. The tailoring of MRF composition in this study achieved high on-state yield stress while ensuring lower off-state viscosity, and also highlighted practical methods to reduce sedimentation. On-state yield stress to off-state viscosity ratios attained exceed conventional industry standards by more than two-fold. This study successfully optimized MRF composition for promising enhancement of prosthetic knee function.

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