THE LIKELY WEAR PERFORMANCE OF CFR-PEEK/CoCrMo FOR ARTIFICIAL JOINTS

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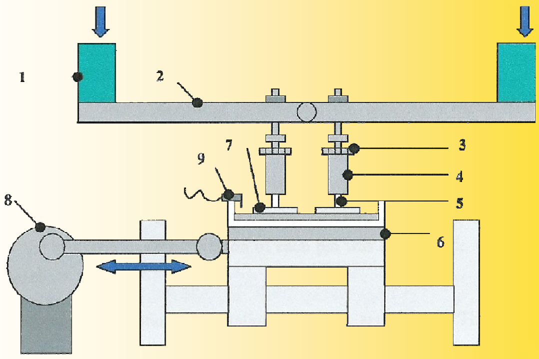
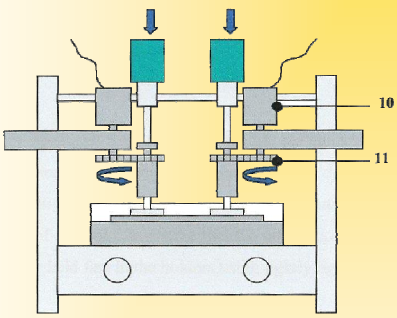
Introduction: Wear particle induced osteolysis is regarded as the most common mechanism of long-term failure of conventional joint replacements. New materials have been introduced for potential use in orthopaedics in an effort to produce bearing surfaces with lower, more biologically compatible wear. Polyetheretherketone (PEEK-OPTIMA) has been successfully used in a number of implant applications due to its combination of mechanical strength and biocompatibility. Wear tests were performed on PEEK-OPTIMA and carbon fibre reinforced PEEK-OPTIMA (CFR-PEEK) against cobalt chrome molybdenum (CoCrMo) to assess the potential of this material combination for use in orthopaedic implants.

Materials and methods:

- Four station pin-on-plate wear machines were used (see Figure 1) and each material combination was tested separately (see Table 1).



1: Load Cell,, 2: Lever Arm, 3: Gear, 4: Pin Holder, 5: Pin, 6: Heater Bed, 7: Plate, 8: Reciprocating Motor, 9: Level Sensor



10: Rotational Motor, 11: Gear

Figure 1: Schematic diagram of the pin-on-plate machine

Pin material	Plate material
PEEK	Low carbon (LC) CoCrMo
CFR-PEEK PAN	Low carbon (LC) CoCrMo
CFR-PEEK PAN	High carbon (HC) CoCrMo
CFR-PEEK Pitch	High carbon (HC) CoCrMo

Table 1: Material combinations used in this study

- Multi-directional motion: reciprocation and rotation (1 Hz).
- 40 N load, 25% bovine serum (protein content 15 gl^{-1}), 37°C, tested to 2 million cycles.
- Wear was assessed gravimetrically and converted to volumetric wear using the material density. The wear volumes were plotted against sliding distance and the gradient of the line through the data (determined by linear regression analysis) provided the wear per metre sliding. This was then divided by the load to determine the wear factor, k ($mm^3N^{-1}m^{-1}$).

Results and discussion: The steady-state wear factors are shown in Figure 2 and Table 2.

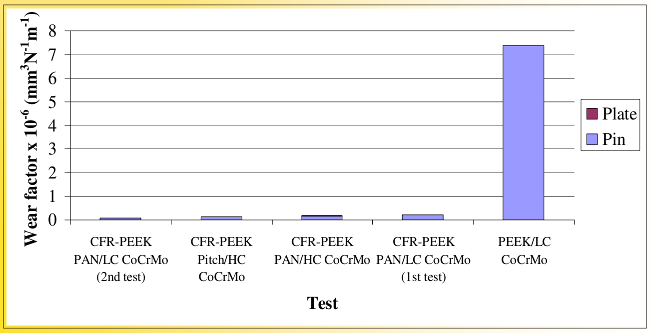


Figure 2: Wear test results for all material combinations

These results show the wear of the components corrected to take account of lubricant absorption. The PEEK/LC CoCrMo produced the highest wear. Both PAN and Pitch-based CFR-PEEK pins were tested against HC CoCrMo plates. The Pitch-based material gave a slightly lower steady-state wear than the PAN-based material. The high carbon CoCrMo material produced similar, but slightly higher, CFR-PEEK wear to the average wear produced against LC CoCrMo.

Test couple	Wear factors (x 10^{-6} $mm^3N^{-1}m^{-1}$)		
	Pin	Plate	Total
PEEK/LC CoCrMo	7.37	0.010	7.38
CFR-PEEK PAN/LC CoCrMo	0.144	0.0112	0.155
CFR-PEEK PAN/HC CoCrMo	0.176	0.00057	0.177
CFR-PEEK Pitch/HC CoCrMo	0.123	0.0058	0.129

Table 2: Average wear factors

Published papers [**1-2**] have shown higher wear factors for ultra-high molecular weight polyethylene against stainless steel (0.55 and 1.1 x 10^{-6} $mm^3N^{-1}m^{-1}$ c.f. 0.14 x 10^{-6} $mm^3N^{-1}m^{-1}$ for the average pin wear for CFR-PEEK PAN/LC CoCrMo).

Conclusions: CFR-PEEK against CoCrMo (HC or LC) provided low wear rates. This study gives confidence in the likelihood of this material combination performing well in orthopaedic applications.

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References: **1. Vassiliou, K.** and **Unsworth, A.** *Proc. Instn. Mech. Engrs. Part H*, 218, 101-107, 2004., **2. Joyce, T.** ***et al***, *Bio-Medical Materials and Engineering*, 10, 241-249, 2000