# Electronic Supplementary Material

# Wear mechanism and debris analysis of PEEK as an alternative to CoCrMo in the femoral component of total knee replacement

**Xinyue ZHANG[1], Tao ZHANG[1], Kai CHEN[2,*], Handong XU[1], Cunao FENG[2], Dekun ZHANG[2,*]**

[1] *School of Mechatronic Engineering, China University of Mining and Technology, Xuzhou 221116, China*

[2] *School of Materials and Physics, China University of Mining and Technology, Xuzhou 221116, China*

Supporting information to https://doi.org/10.1007/s40544-022-0700-z

## S1 Protein degradation and multiple separation and extraction of artificial joint mixed wear debris

1) After the wear test, 10 mL of 25 g/L sodium dodecyl sulfate was added to 10 mL of lubricating fluid, kept in a water bath at 100 °C for 10 min, and then cooled to room temperature.

2) Adjust the pH of the solution to 7.4 with 40.99 g/L sodium phosphate solution and 7.306 g/L ethylene diamine tetraacetic acid (EDTA) solution, and then 1.5 mL 1 g/L papain solution was added and degraded in a water bath at 65 °C for 48 h.

3) 10 mL of sodium dodecyl sulfate solution was added and kept in a water bath at 100 °C for 10 min and cooled to room temperature.

4) Adjust the pH of Tris-HCl solution to 7.6 with 6.057 g/L Tris solution and dilute hydrochloric acid solution, and 0.5 mL 20 mg/mL protease K solution diluted with Tris-HCl solution (pH = 7.6) was added, and then kept in a 55 °C water bath for 24 h.

5) Transfer the solution into a 50 mL centrifuge tube, dilute the counterweight, and then centrifuge at 10,000 r/min for 2 h in a centrifuge.

6) According to different densities, the solution after centrifugation is divided into the upper zone (solution of low-density debris), mixing zone (mixed solution not completely separated), and lower zone (solution of high-density debris). The upper zone solution and the lower zone solution were filtered with a nylon filter membrane with a pore size of 0.05 μm. Then the remaining mixed zone solution was diluted, the centrifuge tube wall was washed, and steps 5) and 6) were repeated three times to obtain the wear debris in different artificial knee joint materials extracted by three times of centrifugation.

7) The filter paper containing the abrasive dust was dried in a vacuum drying oven at 60 °C for 3 h and taken out.

All of the seven processes are shown in Fig. S1.

* Corresponding authors: Kai CHEN, E-mail: cumtck@cumt.edu.cn; Dekun ZHANG, E-mail: dkzhang@cumt.edu.cn

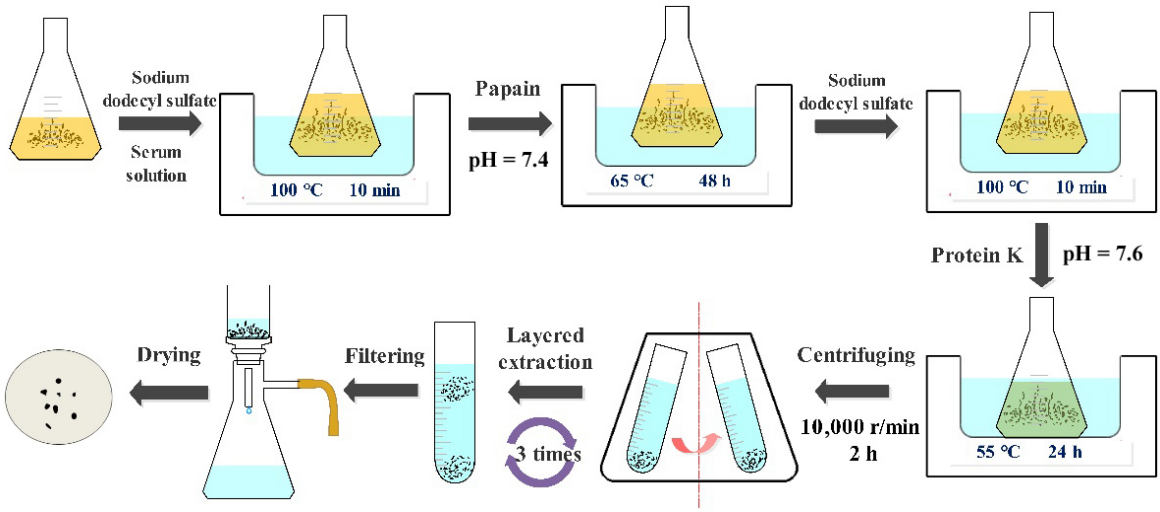


**Fig. S1** Protein degradation and multiple separation and extraction of artificial joint mixed wear debris.

## S2 Verification of cobalt–chromium–molybdenum (CoCrMo) wear debris

Figure S2 shows the energy dispersive spectroscopy (EDS) mappings of CoCrMo wear debris. Although the size, shape, and surface texture of the extracted wear debris are different, the elements of Co, Cr, and Mo appear in the extracted wear debris area simultaneously, and it can be determined that the extracted wear debris is all CoCrMo wear debris. In addition, the EDS results showed that in addition to the large-sized particles, other regions also contained elements such as Co, Cr, and Mo, indicating that besides these micron-scale wear debris, the filter paper also contained a large number of nano-scale CoCrMo wear debris.

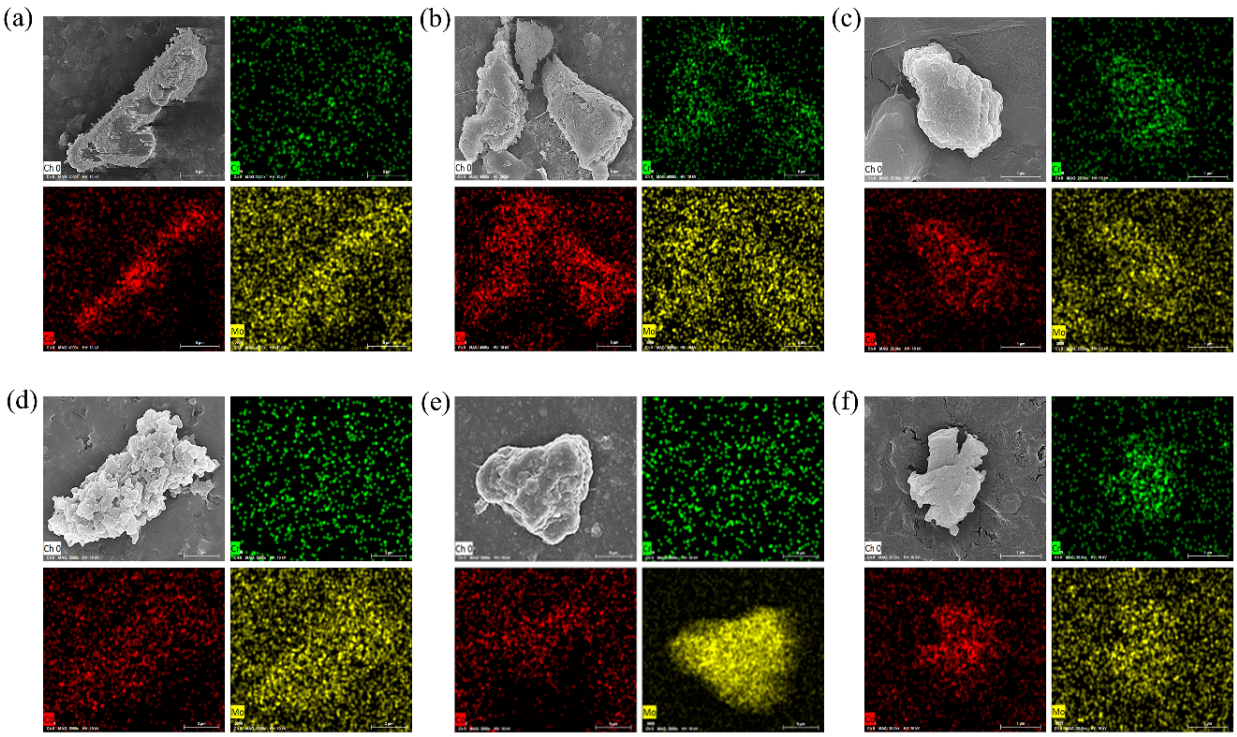


**Fig. S2** EDS mappings of CoCrMo wear debris: (a) 0.5 million cycles, (b) 1 million cycles, (c) 2 million cycles, (d) 3 million cycles, (e) 4 million cycles, and (f) 5 million cycles (the green is Cr, the red is Co, and the yellow is Mo).

## S3 Wear loss simulations in 10 million cycles

The wear losses of XLPE tibial pad in PEEK–XLPE and CoCrMo–XLPE were linearly fitted with the software (OriginLab, USA). The results are shown in Fig. S3. The wear loss obeys the equations of PEEK–XLPE: $Y = 6.572X - 2.43065$ and CoCrMo–XLPE: $Y = 6.964X + 0.17526$, where $Y$ (unit: mg) is the wear loss of XLPE, and $X$ (unit: million) is the wear cycle. For the calculation of the above fitting equations, when the number of wear cycles is 10 million, the wear loss of the XLPE in PEEK–XLPE is about 63.3 mg, and that in CoCrMo–XLPE is about 69.8 mg. Both of them have good wear resistance. The wear loss of XLPE in PEEK–XLPE is lower than that in PEEK–XLPE after 10 million cycles.

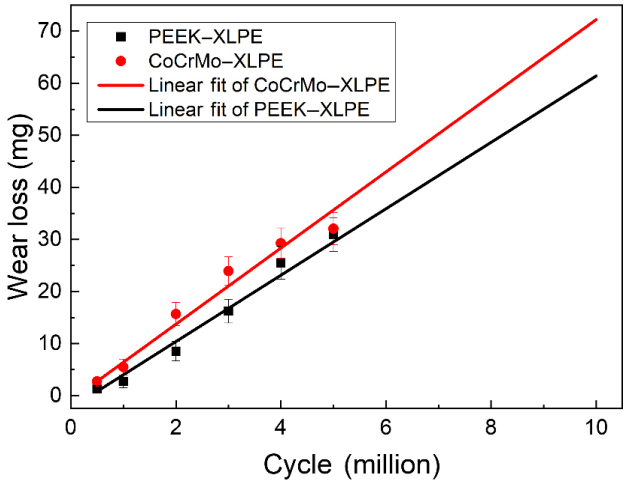


**Fig. S3** Fitting curves of awear loss of XLPE tibial pad.