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Nutrient and Wind Effects on Dragline Properties: Perspectives from WAXS & SAXS

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Spider dragline silk is one of the strongest nature fibers and some of their features are even better than those of the best synthetic fibers. Understanding the mechanisms inducing silk variability may have implications for biomimetics and the synthesis of environmentally responsive materials. Dragline silk contains both elasticity (amorphous) and crystalline regions. Our previous studies had demonstrated that spiders might vary the protein composition and thus physical properties of silks when experiencing food with different nutrient level. In this study we fed Nephila pilipes with high, low and no protein foods and collected their dragline silks for synchrotron Radiation (SR) wide-angle X-ray scattering (WAXS) and small-angle X-ray scattering (SAXS) examinations. The WAXS data showed a significant difference in crystalline fractions of dragline silks produced by N. pilipes experiencing different food treatments. In addition, the orientation of crystallines also varied considerably among silks produced by spiders in three treatment groups. The SAXS data, obtained with the beam incident along and perpendicular to the fiber axis revealed a mesostructure comprising nano crystallites (beta sheets) stack spirally along the spider fibril axis. Such results indicate that spiders experiencing different nutrient stress level might produce dragline silks of different physical properties due to variations in crystalline density, orientation and the meso-phase structures in nano scale. Furthermore, varying environmental wind strength leads to changes in tensile mechanics of spider dragline silk hence produced. Exposing the spider Cyclosa mulmeinensis to controlled stress from constant airflow, we found correlated changes in (i) amino acid composition, (ii) tensile mechanics and (iii) crystallinity, of the dragline silk; which results suggest that protein variation and/or post secretion crystalline variations are associated with the mechanical properties of the spider silks.

Keywords: spider dragline silk, Nutrient level, Wind Effect