

Asphaltene physics and chemistry – A passion of Professor Teh-Fu Yen

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As a naturally occurring chemical species, asphaltene was treated and researched as a chemistry topic until Professor Teh-Fu Yen decided that it was a physical process that bore this complex child. His landmark X-ray work in 1961 with Pollack, an X-ray crystallography expert, provided a detailed anatomy of several asphaltenes of different origins [1]. In this article, Prof. Yen proposed a colloidal model for an asphaltene aggregate that opened an asphaltene research era (see the original figure below).

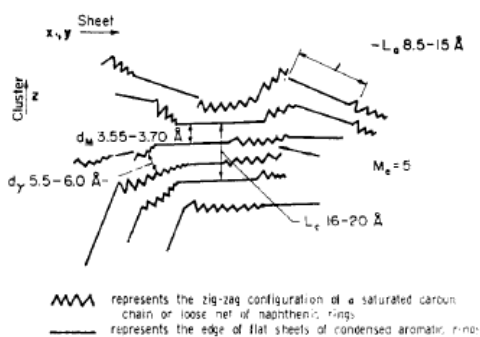


Fig. 1 The original asphaltene figure proposed by Prof. Yen.

Prof. Yen's structural model has been agreed with, used, proved, disagreed with, trashed, reconfirmed, and re-trashed many times. Today, there are researchers who agree and disagree with this original model. However long the controversy lasts, it is clear that his vision and his simple model have endured for more than half a century, an enormous accomplishment. Within a year after publishing his original paper, Prof. Yen applied electron spin resonance, infrared, NMR, mass spectroscopy, and small angle X-ray (SAXS) to study asphaltenes [2-6]. These techniques allowed him to study a length scale ranging from atomic to colloidal structures. Clearly, he wanted to sort out the structure and determine the underlying chemistry and physics that creates such a complex species [7].

In his 1970SAXS scattering paper, he compared the asphaltene dimensions with those derived from other techniques [8]. Most researchers agree that the SAXS data he published are, in fact, very accurate. Most importantly, his analyses did not involve any curve fitting, which often suffers from ambiguity because of non-linear converging process. Rather, he applied the surface and geometric analyses that are data-dependent only. One may disagree with the

sensitivity of the results, but one should not doubt the accuracy of the analysis.

On the chemistry front, Prof. Yen conceived of linking vanadium complexes, iodine complexes, and porphyrins to asphaltene structures in an attempt to rationalize the aggregate structure from the charge transfer angle [9-11]. This development opened a new research field for the next several decades.

As a young researcher in 1986, I had an unforgettable conversation with Prof. Yen that led me to the world of asphaltenes. At the dawn of the small angle neutron scattering (SANS) technique, almost 30 years after Prof. Yen proposed the asphaltene model, we applied this new technique and found his model dimensionally correct [12]. From 1986 on, SANS and SAXS were heavily used in asphaltene research, and numerous models were applied for data analysis, mostly model-dependent analysis. These models could be sensitive, but they could also be incorrect. Nevertheless, the modeling competition brought new blood to the field.

Tracing Prof. Yen's vision and passion as well as many great research papers published after his landmark work, I studied this new world of asphaltenes using macroscopic techniques (surface tension, viscosity, and DSC) and microscopic ones (SANS, SAXS, and inelastic neutron scattering). I hoped to find a physical basis for asphaltenes, which seem to differ from classical complex fluids in several important respects [13].

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