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This Week's Citation Classic

Calderbank P H & Moo-Young M B. The continuous phase heat and mass-transfer properties of dispersions. *Chem. Eng. Sci.* **16:**39-54**,** 1961. [Dept. Chemical Technology, Univ. Edinburgh, Edinburgh, Scotland]

Techniques have been developed for measuring the interfacial area in gas-liquid dispersions. The results have been combined with other published data for heat and mass-transfer in liquid-liquid and solid-gas dispersions. [The *SCI*® indicates that this paper has been cited over 170 times since 1961.]

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"This work was carried out at a government research centre in England with the object of providing basic data for the fermentation industry at a time when biochemical engineering was thought to be in the ascendancy. It was in fact the final phase in a three-part program. The earlier parts had been designed to understand and evaluate the dispersion efficiency of aerated mixing vessels which are required to provide rapid transfer of oxygen from sterile air to the nutrient fluid used in aerobic fermentations of the kind by which penicillin is manufactured. The final phase was an attempt to measure and correlate the rate of transfer of oxygen and other gaseous solutes from gas bubbles to an agitated turbulent liquid in which they were formed and through which they rose as a cloud. This situation is also met with and is of interest to several other chemical engineering operations, such as distillation, and offered an opportunity to enlarge the scope of the work so that it later flowed naturally into other fields of topical importance.

"The work took place at a time when some simple ideas concerning the nature of turbulence were current and these ideas were applied with some success to the results obtained both in respect of fluid dispersion and solute transfer rates, so that rather attractively simple relationships were established between these properties and the amount of mechanical energy employed as fluid turbulence to enhance them. These relationships were of such a general form as to make them of interest over the last decade to a variety of research workers in the fields of turbulence as well as to design engineers concerned to estimate the energy requirements of plants in which fluid turbulence is used to increase the rate of otherwise slow diffusional processes, thus accounting for the frequent citation of this paper.

"My colleague, now Professor M.B. Moo-Young, has maintained his interest in fermentation at Waterloo University and turned his attention to the practical problems of the conversion to protein of vegetable matter such as straw and bagasse, matters of great importance to projected world food resources and the better utilisation of solar energy. My recollection of the time when we worked together is most agreeable; a great deal of sometimes tedious experimental work was carried out but this was made more interesting through the simultaneous development of new experimental techniques. One such, which exercised us for a long time, was a light obscuration method to measure the gas-liquid interfacial area in bubble clouds in which the bubbles are made to appear as black bodies and only that light which meets no obstruction is recorded. We later found that such a method had been developed much earlier by Sauter[1] for the study of carburettor sprays, although using methods of visual comparison in place of our electronic recording. If we had been conversant with the German mechanical engineering literature, we would have saved ourselves a good deal of time but I think our pleasure in the success of this instrument was actually increased by the knowledge that it had an honourable past record."

1. **Sauter J.** *Forsch. Art. Geb. Ing.* **312**:2-8, 1928.