# AGGLOMERATION of SOLID PARTICULATES

*S.Sigrist[1], J.Lahaye[1] and R.Jullien[2]*

*[1]Institut de Chimie des Surfaces et Interfaces 15, rue Jean Starcky 68057 Mulhouse Cedex*
*[2]Laboratoire des verres Université de Montpellier 34095 Montpellier Cedex 05*

## Introduction

The presence of micrometric particles in the air is a potential danger for human health. The risk is correlated to the aerosol stability in the ambient air. The present work addresses the agglomeration of divided solid materials with average size below 10 µm.

## Experimental

Two different carbon blacks from Degussa were used for the study : a furnace black (Printex 60 : PX) and a gas black (colour black S160 : GB). The initial particle size distributions of the carbon blacks were determined by laser diffraction The samples dispersed in xylene were characterized using a Coulter LS 130 granulometer (Figure 1 ) ( Table 1 ).

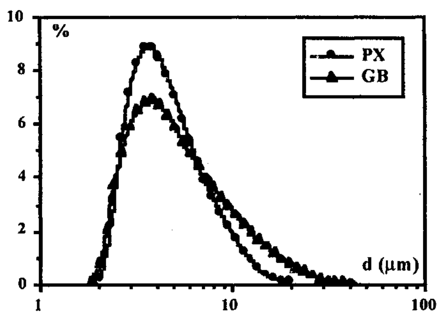


Figure 1. Size Distributions

The agglomeration was performed in a vertical tube 10 cm inside diameter and 80 cm height. The sample is deposited on a sintered glass disk welded at the bottom of the cylinder. At the top of the tube is fixed a membrane in polycarbonate (Millipore) with calibrated pores of 1.2 µm. The aerosol is generated by a nitrogen stream through the sintered glass. The nitrogen stream goes through the membrane at the top of the cylinder while the particles are retained. The parameters, namely the nitrogen flux and the duration of experiment are adjusted to avoid multiple collisions on the membrane which would artificially increase the appearing size. The samples deposited on the membrane are observed by optical microscopy. The micrographes are treated by image analysis. Each particle is determined by :

- the area S of its planar projection,
- the length L and width l of the circumscribed rectangle,
- the diameter of the circle with the area equal to S. The size distribution is characterized by the mean arithmetic diameter d and the standard deviation.
- the dimension T of is defined by the relation $T= (L.l)^{0.5}$

## Results and Discussion

The results were obtained for a nitrogen flow of 10 l/min and a duration of 30 s. A series of five experiments leads to the same mean diameter and standard deviations. On the one hand, the method is reproducible and, on the other hand, the agglomeration of the carbon black samples is significant : the mean diameter si multiplied by a factor of 4 within 30 seconds.

The fractal dimensions D of the two carbon blacks have been determined using a mass - size relation :
$S= k.T^{D}$ [1]

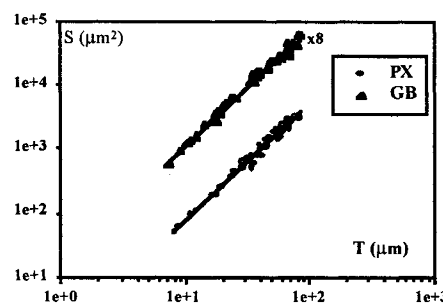


Figure 2. Surface of agglomerates versus Size

The experimental fractal values are 1.85 and 1.77 for Printex and Gasblack, respectively.
These values have been determined from the bi-dimensionnal projections of the real aggregates and agglomerates. It was interesting to check whether these experimental results agree the model developed by Thouy et Jullien (1)
Using this model, tridimensionnal aggregates of 8 to 128 particles per aggregates with a fractal dimension between

1.4 and 2.0 were generated. These aggregates were projected on a plan and the surfaces of the projected aggregates were determined by the method previously used for the two carbon black samples. The fractal dimension D' of the projected particles were computed from the expression

$$S/S_0 = K' (T/T_0)^{D'} \qquad (2)$$

with $T_0$ : the size of the primary particle
$T$ : the size of the aggregates ( or agglomerates )
$S_0$: the surface of the primary particle
$S$ : the surface of the aggregates or ( agglomerates )
The results are plotted in table 2

From the equations 1 and 2 and in assuming that the agglomerates are almost spherical, it can be written:

$$S_0 = \pi/4\ T_0^2$$
$$S = \pi/4\ K'\ T_0^2\ (T/T_0)^{D'}$$
$$S = \pi/4\ K'\ T_0^{2-D'}\ T^{D'}$$

For the lower cutoff, T is equal to the size of the primary particle i.e. $T_0$ and

$S = \pi/4\ K'T_0^2$ , for the projected simulated agglomerates

$S = K\ T_0^D$ , for the PX and GB agglomerates
Therefore, $T_0^{2-D} = 4/\pi\ K/K'$

The values of $T_0$ were computed from the measured values D, K and K'. They were compared to the size of the agglomerates obtained by laser diffraction (Table 3 ). A fairly good agreement is obtained between the values determined from the projected simulated particles and those from the two carbon blacks samples. The higher difference in size observed for the GB could be imputed to a higher polydispersity of the agglomerates (the simulated values are obtained by the agglomeration of monodispersed spheres).

The experimental results obtained with the two carbon blacks samples agree the theoritical model of Thouy and Jullien for the generation of aggregates and their planar projections.

## Reference

R. Thouy and R.Jullien J.Phys.A: Math.Gen. 27 , 2953 (1994)

Table 1 Dimension of Initial Samples

| | Mean Diameter (µm) | Standard Deviation (µm) |
|---|---|---|
| PX | 5.3 | 2.7 |
| GB | 6.7 | 4.8 |

Table 2 : Fractal Dimension of Simulated Aggregates

| Tridimensionnal fractal dimension of simulated aggregates | Experimental fractal dimension of the projected simulated aggregates |
|---|---|
| 1.4 | 1.55 |
| 1.6 | 1.67 |
| 1.7 | 1.66 |
| 1.8 | 1.70 |
| 1.9 | 1.74 |
| 2.0 | 1.77 |

Table 3 : Comparison between Computed and Experimental Primary Aggregates

| Samples | D | D' | K | K' | $T_0$( mm ) | Exp. value(mm) |
|---|---|---|---|---|---|---|
| PX | 1.85 | 2.0 | 1.05 | 1 | 6.5 | 5.3 |
| GB | 1.77 | 1.9 | 1.37 | 1.04 | 10.4 | 6.7 |