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The Durability of Three-Way-Catalyst-Particles Membrane Filter for Fluid-Dynamic Shear Stress

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It is required to install Gasoline Particulate Filters (GPFs) in addition to the conventional Three-Way-Catalyst (TWC) to achieve zero emission vehicles because Particulate Matters (PMs) are included in exhaust gases emitted from gasoline direct-injection engines. Here, a TWC particles membrane filter proposed by the authors is useful to achive almost 100 % filtration efficiency from the beginning of soot trapping and a higher purification of pollutant gas components compared with the conventional after-treatment systems. In the current study, durability of the TWC particles membrane filter was investigated experimentally using a fluid-dynamic shear stress method proposed here.

The TWC particles membrane filter was manufactured by deposition of TWC particles with a diameter around 1 micron suspended in a working gas using a wall flow system as shown in Fig.1 (left). After that, the exit plug was switched to make a straight flow in the deposited channels as shown in Fig.1 (right) to make a constant shear stress on the surface of the TWC membrane filter. The total amount of TWC particles deposited was 0.03596g. After deposition, the membrane layer was sintered at 973 K during 4 hours.

Dry nitrogen gas was introduced into the TWC particles deposited channels with an average velocity of 7.1 m/s. The weight of the sample (TWC particles membrane filter) was measured at each elapsed time of 10, 40, 100, 160, 1600 minutes as shown in Table 1. The peeling amount of a fragment of TWC particles membrane filter was calculated through the weight difference between the initial and measured weights at each elapsed time. An average peeling rate at each time interval such as 0 – 10, 10 – 40, 40 – 100, 100 – 160, 160 – 1600 is estimated and plotted as shown in Fig.2. Simultaneously, a fitting curve shown by the following expression is depicted.

$$Peeling\ rate = Be^{-At} \quad (1)$$

Here, t is the elapsed time. A coefficient A is determined by the least squares method using all experimental data, while B is the vertical intercept of a straight line passing through two experimental data close to $t = 0$. The total peeling amount of TWC particles can be estimated by integrating the fitting curve from zero to infinite time. The estimated peeling amount was 3.35% of the initial weight of TWC membrane layer while the measured one from zero to 1600 minutes was 3.31%. Aa a result, the peeling experiment during 1600 minutes is enough for the durability test and the peeling amount is acceptable under the condition of the current sintering process.

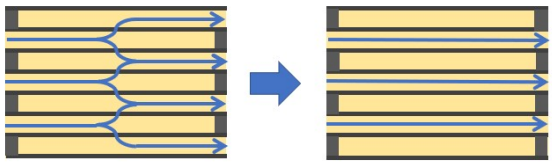

Fig. 1 Wall flow for TWC particles trapping (left) and straight flow for peeling experiment (right)

Table 1 Weight of TWC particles peeled off with elapsed time

Elapsed time [min]	Sample weight [g]	Weight of particles peeled off [g]
initial	1.09731	
10	1.09711	0.00020
40	1.09670	0.00061
100	1.09638	0.00093
160	1.09617	0.00114
1600	1.09612	0.00119

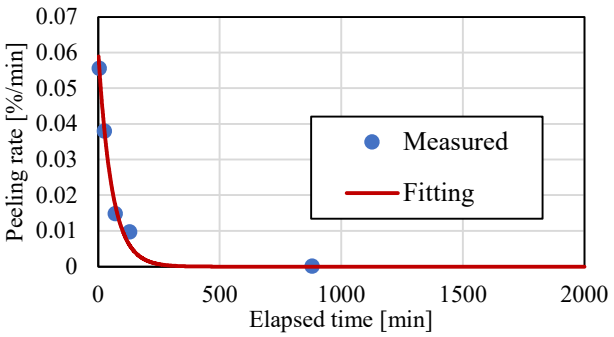

Fig. 2 Peeling rate with elapsed time