# Capacitance effect of porous bed material - an approach to improve conversion of volatile matter within fluidized bed -

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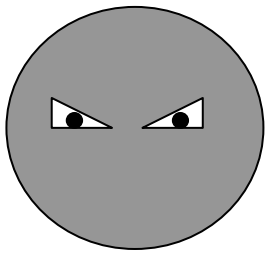
# Background of the present work

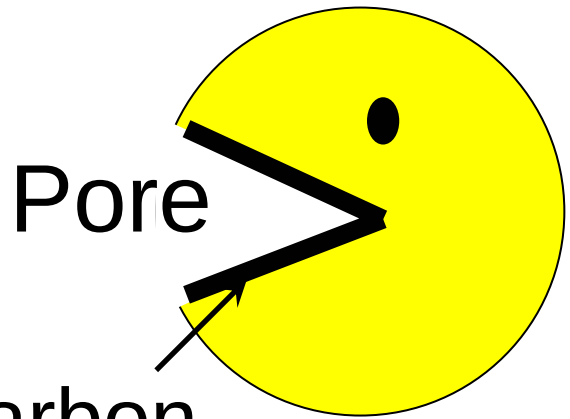
- Biomass (or plastics, municipal wastes, sludge, etc.) : High volatile matter fuels
- High conversion of V.M. is important to attain high plant efficiency. However, conversion of V.M. in the dense bed is often poor since V.M. evolution occurs at upper surface of the dense bed.
- Insufficient conversion of V.M. results in troubles such as tar deposition and dioxin formation in back-pass.

# An approach to improve V.M. conversion: capacitance effect

V.M., tar



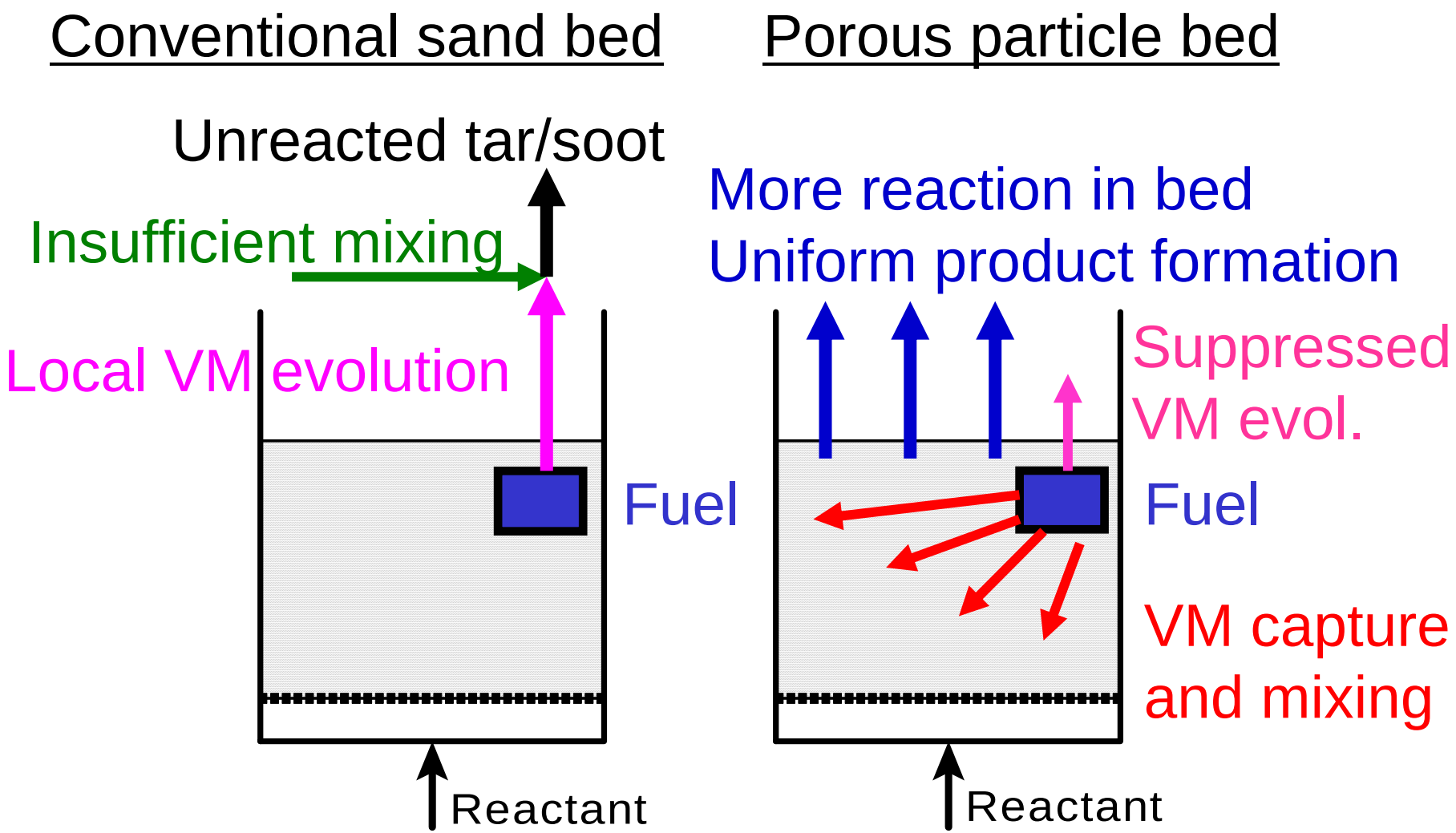
Porous solids




Porous particles capture V.M. at high temperatures; carbon deposit is formed within pores.

→ Increased residence time of V.M.

# Expected advantages of porous bed material in comparison to sand bed

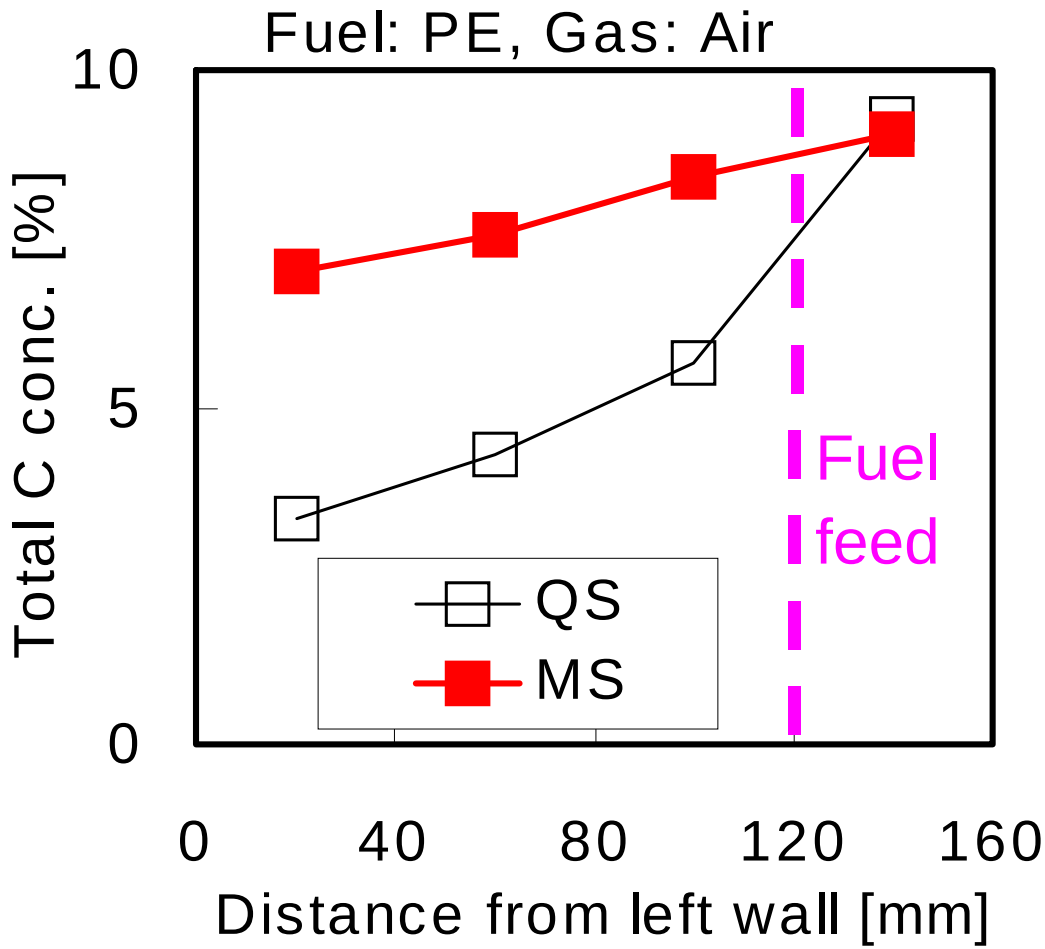


# Improved horizontal dispersion by porous bed material during plastic pellet combustion

Total carbon
$=CO_2+CO$
$+CH_4+2C_2H_n+\ldots$
measured in freeboard

QS (non-porous): non-uniform gas dispersion

MS (porous) : uniform gas dispersion



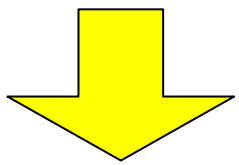

Shimizu, J. Japan. Inst. Energy, 80, 333 (2001)

# Reaction rates are not yet available!

For the rational design of reactors, reaction rates are necessary.

1)volatile matter capture

2)removal of carbon deposit from the bed material by combustion or gasification



Kinetic study was conducted in this work.

# Present work

- Volatile matter capture by porous bed materials was conducted in an inert atmosphere at 650 - 850 $^{o}$C using a fixed bed reactor.

- Burning rate of the carbon deposit over porous bed material was also measured.

# EXPERIMENTAL

# Porous bed materials

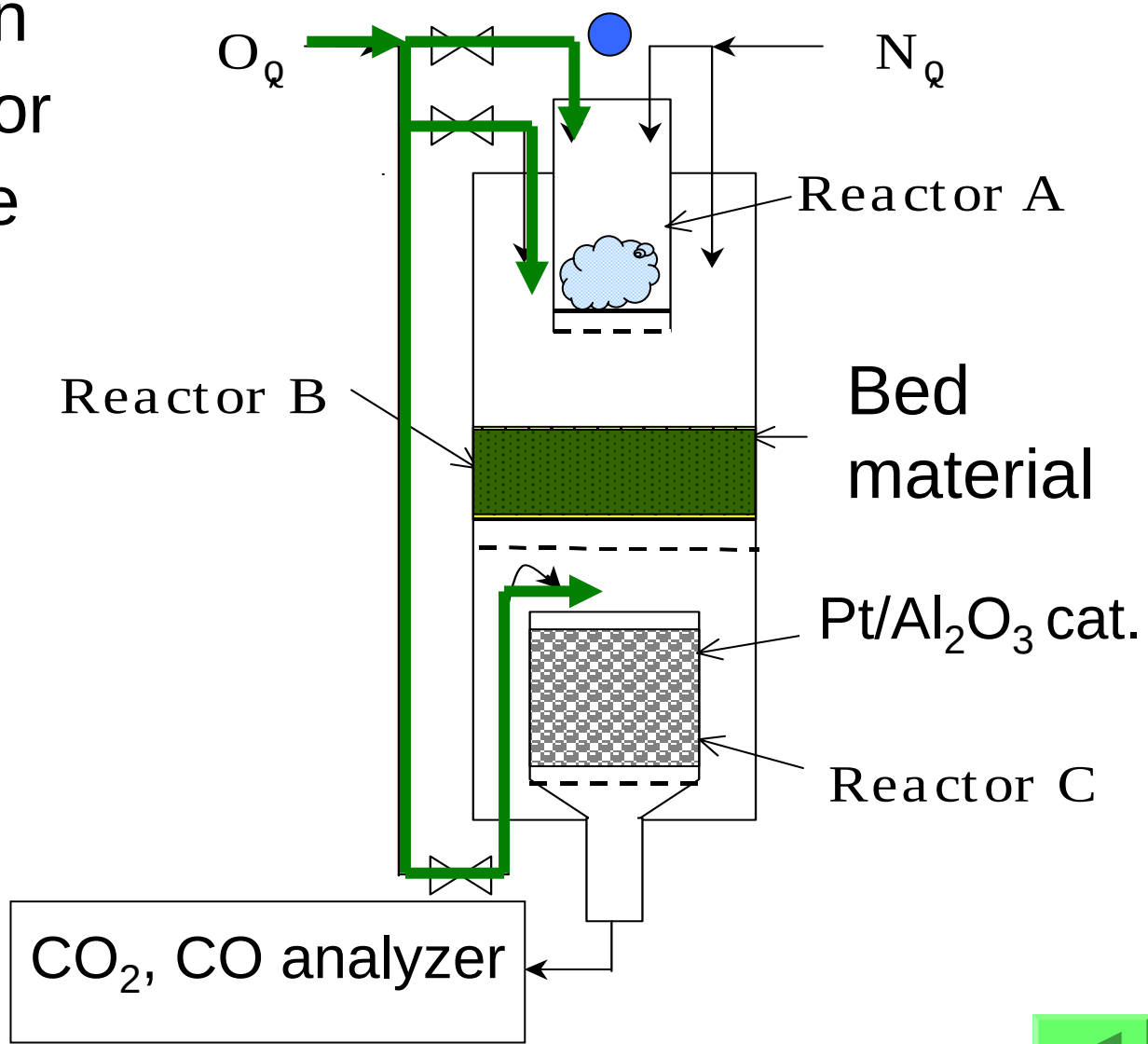
| | MS | MS-1B | Activated Bauxite |
|---|---|---|---|
| Size | 0.75 mm | 0.4 mm | 0.4 mm |
| $Al_2O_3$ | 91.32 | 84.7 | 69.4 |
| $SiO_2$ | n.a. | 2.2 | 7.2 |
| MgO | 0.15 | 0.0 | 0.0 |
| CaO | 0.07 | 0.8 | 0.3 |
| $TiO_2$ | n.a. | 1.1 | 13.0 |
| $Fe_2O_3$ | 0.54 | 5.8 | 8.4 |
| $SO_3$ | 2.10 | 3.8 | 0.8 |
| Others | n.a. | 1.6 | 0.9 |
| Area [$m^2/g$] | 187 | 195 | 124 |

# Fixed bed reactor

Step1: Evolution of V.M. in reactor A. V.M. capture in reactor B.

Step2: Deposit combustion.

Step3: Char combustion in reactor A.



# Experimental conditions

Temperature: 650 – 850 $^{o}$C

Reactor i.d.: 27 mm

Solid bulk volume: 26 $cm^3$

Total gas flow rate: 2.2 Nl/min

Fuel: Polyethylene (V.M. 100 %)

$O_2$ concentration during deposit carbon combustion: 7- 21 %

# RESULTS AND DISCUSSION

# A typical result of fixed bed study

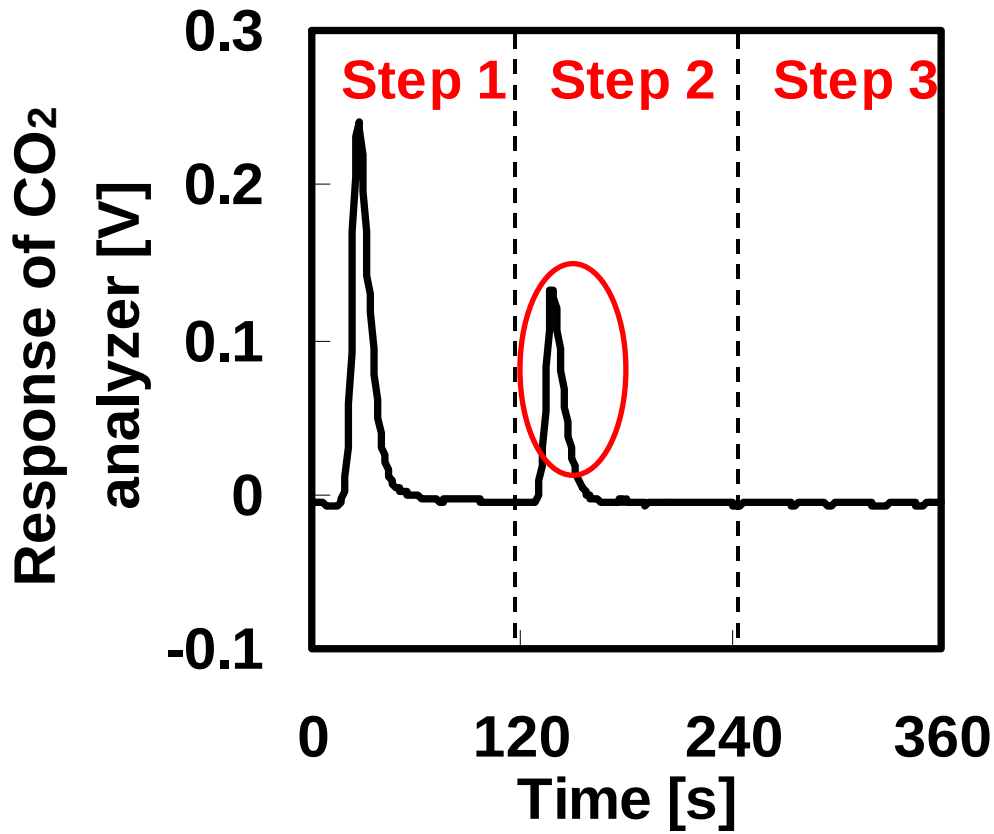
## Signal from $CO_2$ analyzer

Solids: MS

1: V.M. evolution (Part of V.M. was not captured by solids.)

2: Deposit combustion

3: Char combustion



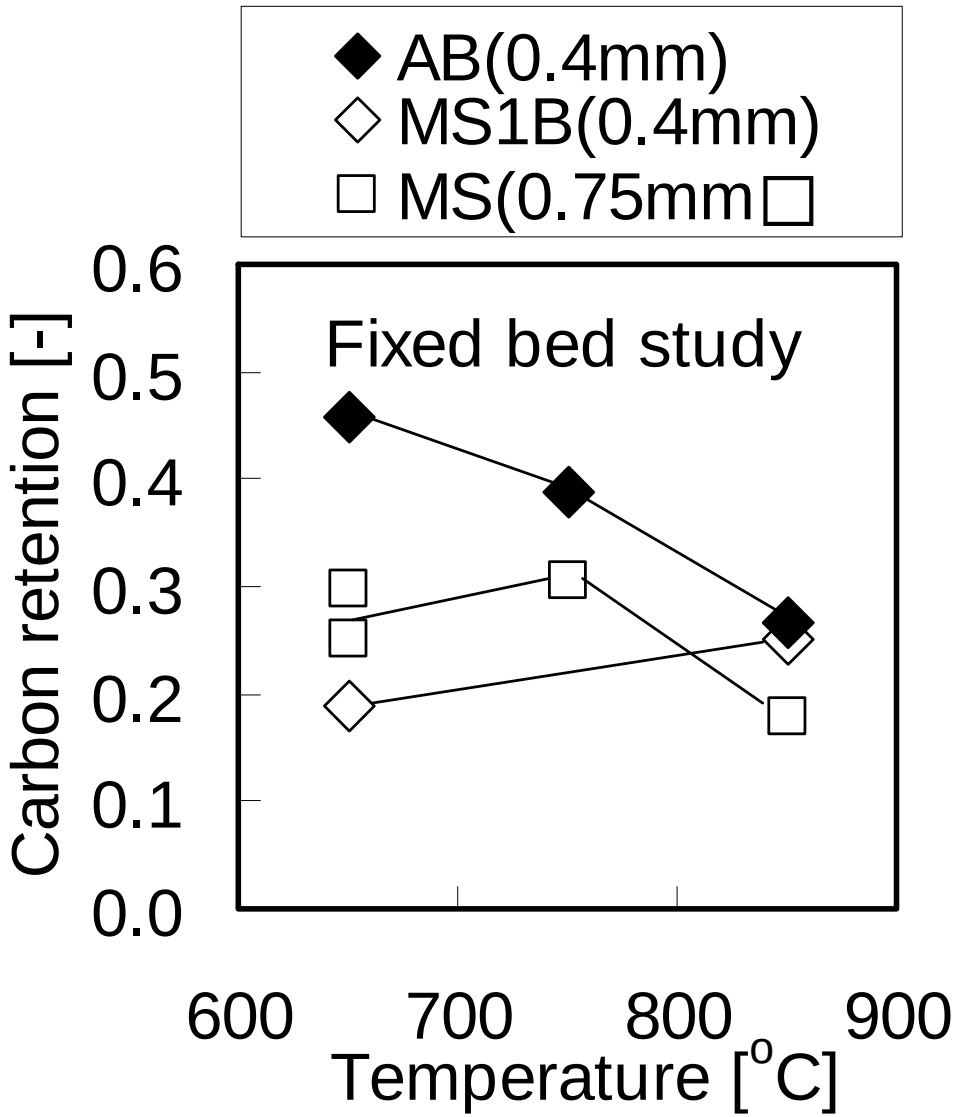

From $CO_2$ formation during step 2, the amount of carbon deposit was determined.

$O_2$21% 650

# Effect of temperature on V.M. capture

Carbon retention
=(deposit)/(feed)

Carbon retention and the effect of temperature on it differed among bed materials.

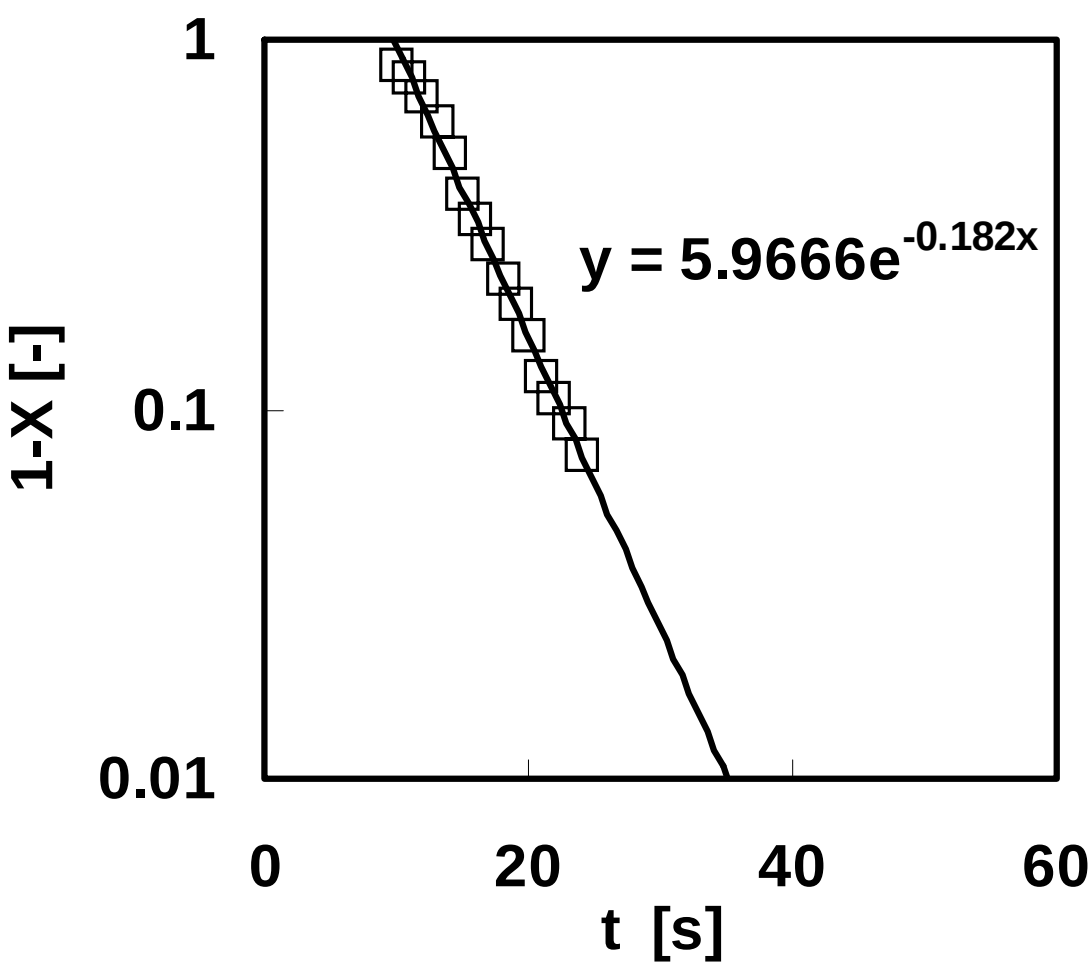


# Burning rate of carbon deposit

Burning rate of carbon deposit was measured at $O_2$ concentration 7 -21 and 650 - 850 $^oC$.

Reaction rate was given as follows:

$dX/dt=k(1-X)$




(MS 0.75mm, $O_2$21%, 650 )

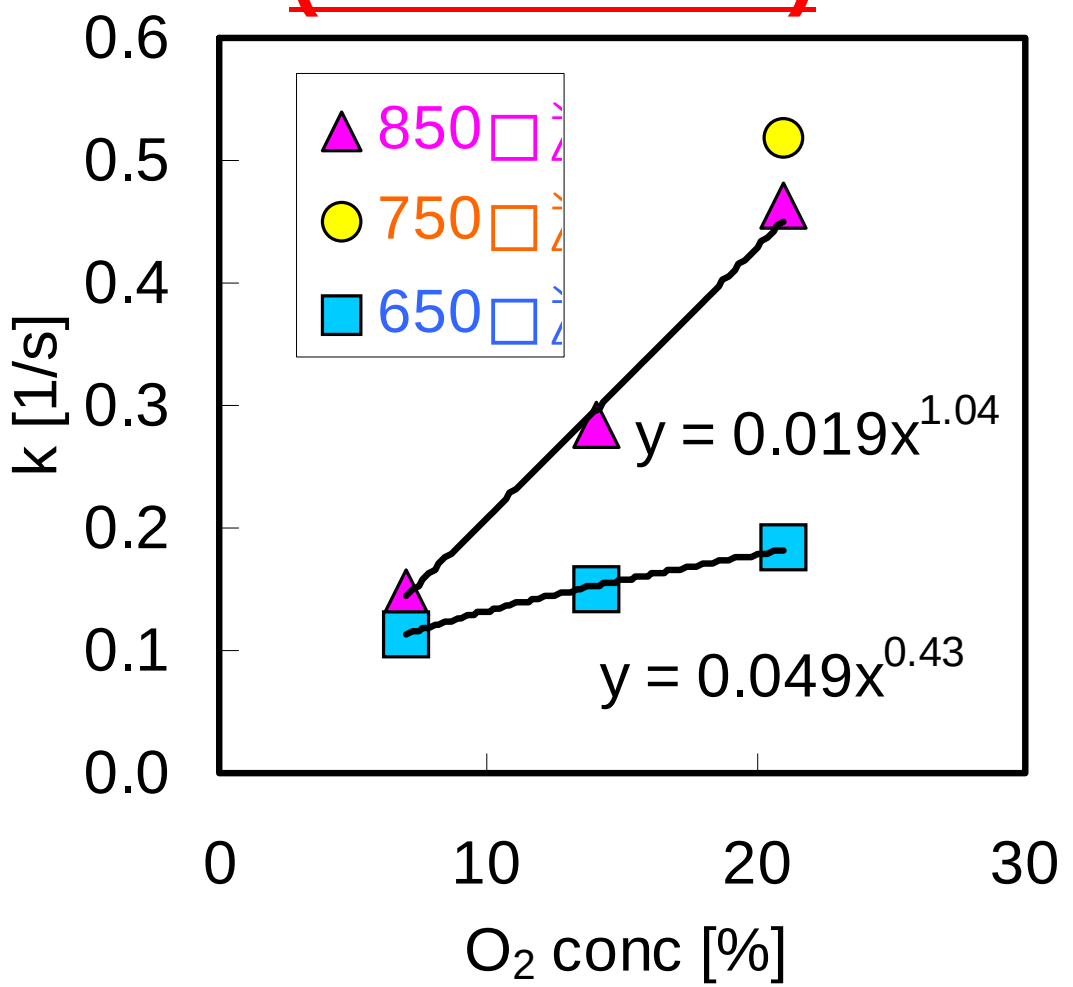
# Effect of $O_2$ concentration on k

No increase in k with increasing temperature from 750 to 850 °C.

Diffusion controlling at temperatures above 750 °C

At 650 °C, reaction order with respect to $O_2$ was 0.43.

**(MS 0.75mm)**

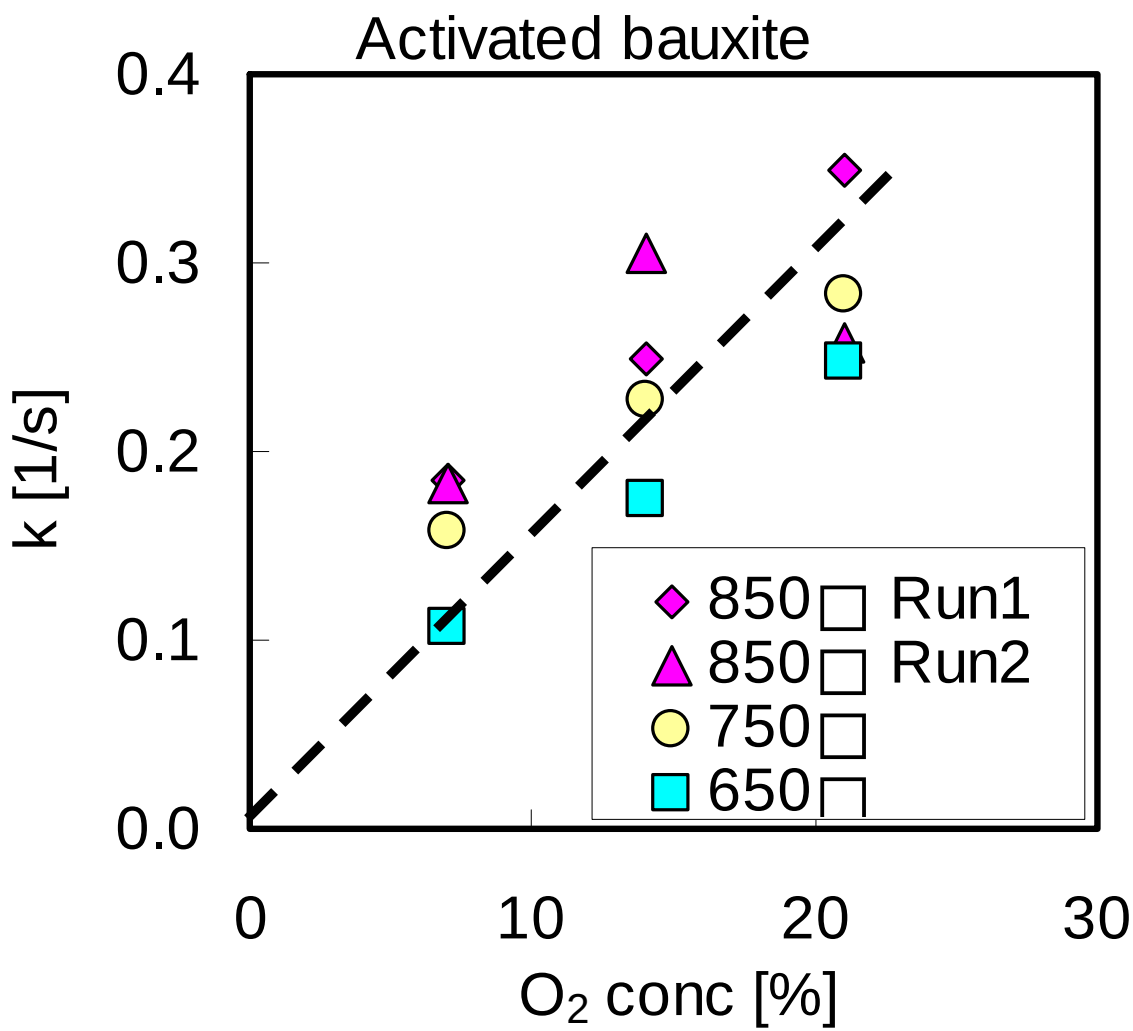


# Effect of $O_2$ concentration on k

## AB (0.4 mm)

No increase in k with increasing temperature from 650 to 850 $^oC$.

Diffusion controlling at temperatures above 650 $^oC$



# CONCLUSION

An experimental procedure was proposed to evaluate the volatile matter capture by porous bed materials and its regeneration rate.

**V.M. capture by porous bed material**

- The effect of temperature on carbon retention depended on type of bed material.

**Burning rate of carbon deposit**

- Carbon burn-up rate differed among bed materials.

# ACKNOWLEDGEMENT

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