Reactivity of wood charcoal with ozone

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Objective

For stopping or mitigating global warming, utilization of wood-derived charcoal or carbonized biomass is proposed.

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This proposal is based on high stability of charcoal.

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But few scientific data for chemical degradation of wood charcoal is available.

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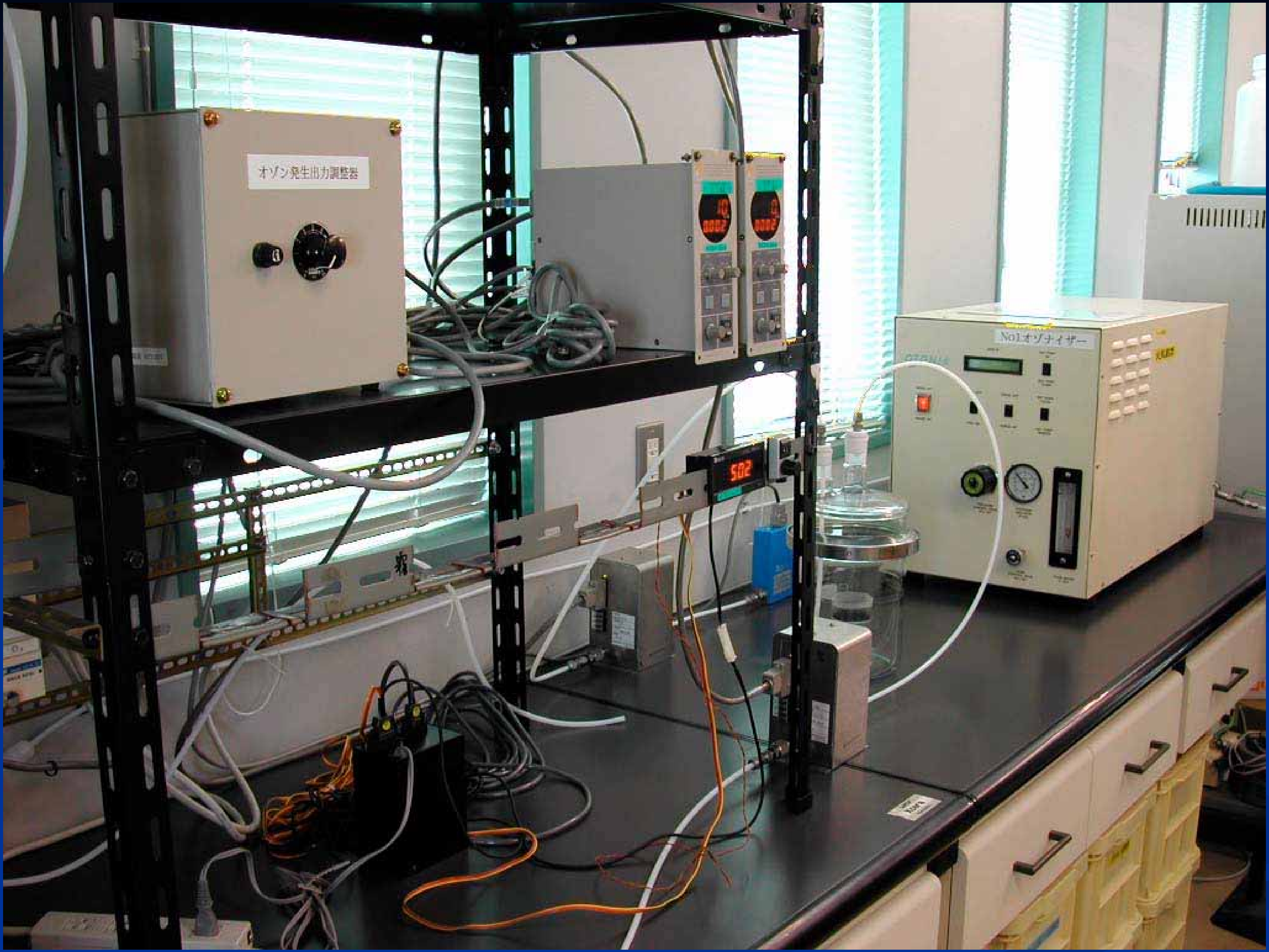
In this study, a half-life of wood charcoal with ozone in air is estimated.

Materials & methods

Samples for ozone treatment

Sample name	Sample type	Original material	Carbonizing temperature (ºC)	Size (mm)
C-400	Charcoal	Beech sawdust	400	< 2
C-1000	Charcoal	Beech sawdust	1,000	< 2
AC	Activated charcoal	Coconut shells	—	0.5–5
GR	Graphite	Natural graphite	—	Powder



Ozone exposure (whole system)

Ozone exposure (reaction vessel)

Analysis and estimation

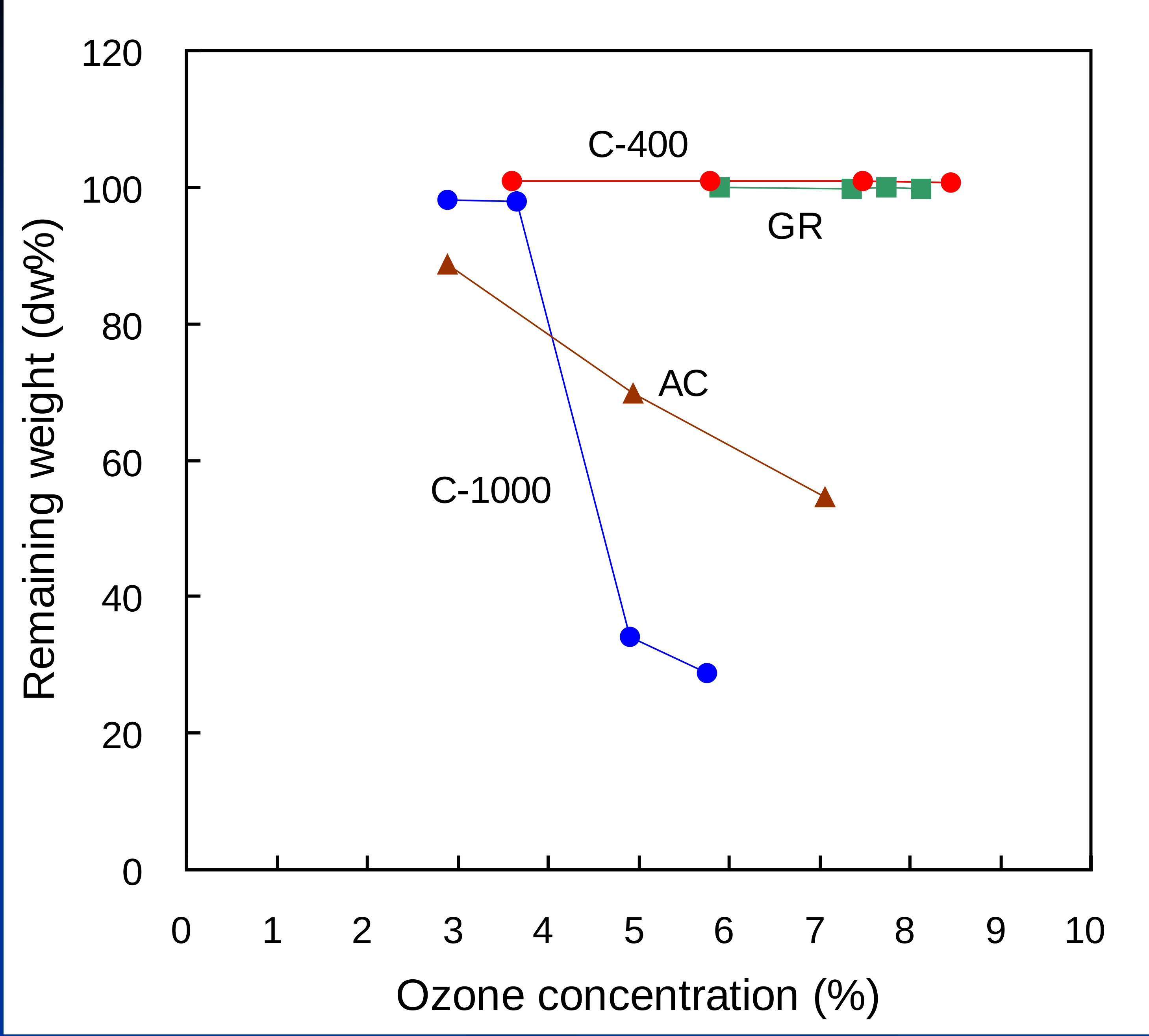
1. Weight changes of the samples

2. Observation of surface morphology of the samples by scanning electron microscopy

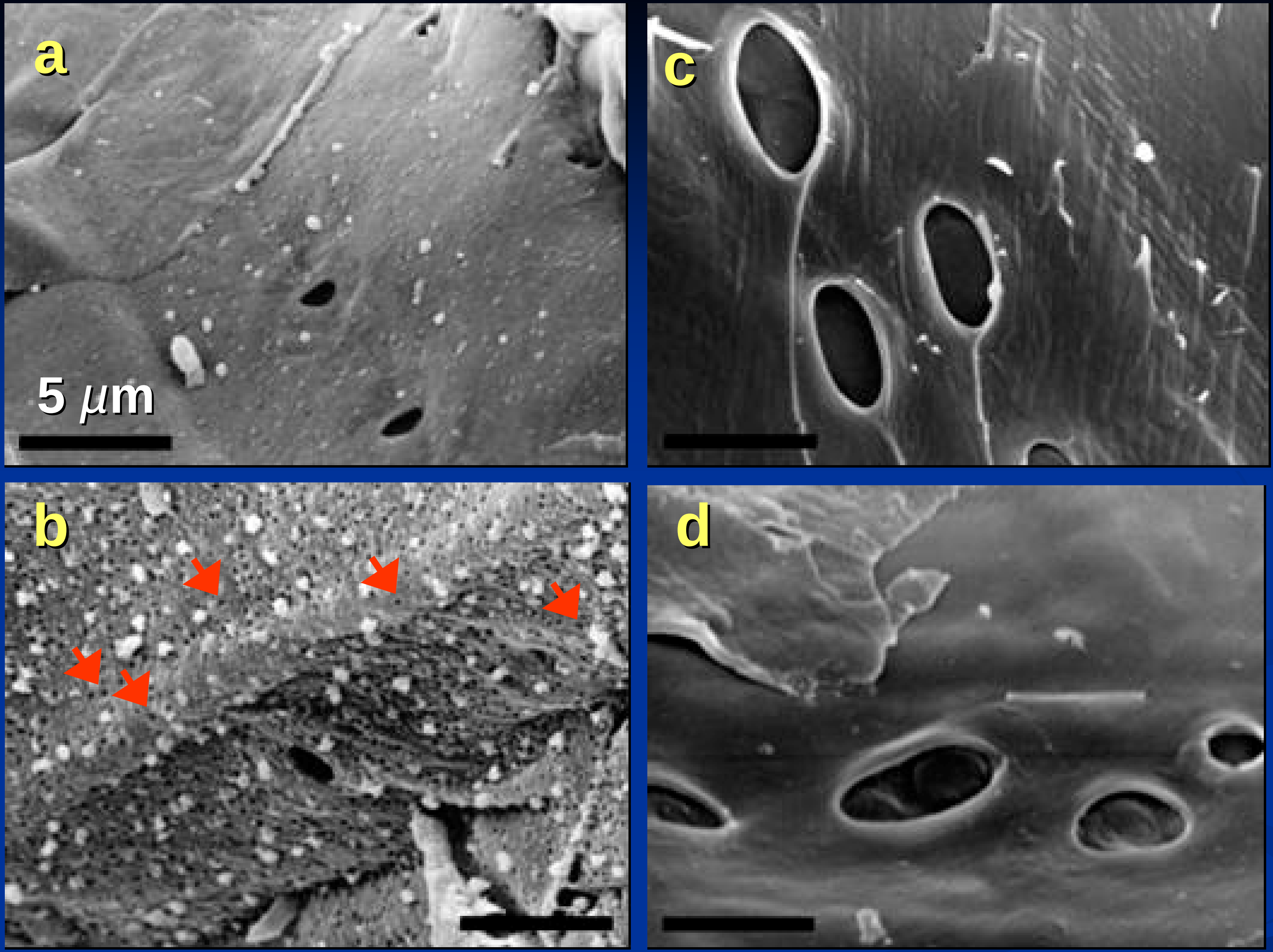
3. Analysis of surface chemical structure of the samples by X-ray photoelectron spectrometer

4. Estimation of the half-life of the samples with ozone in air

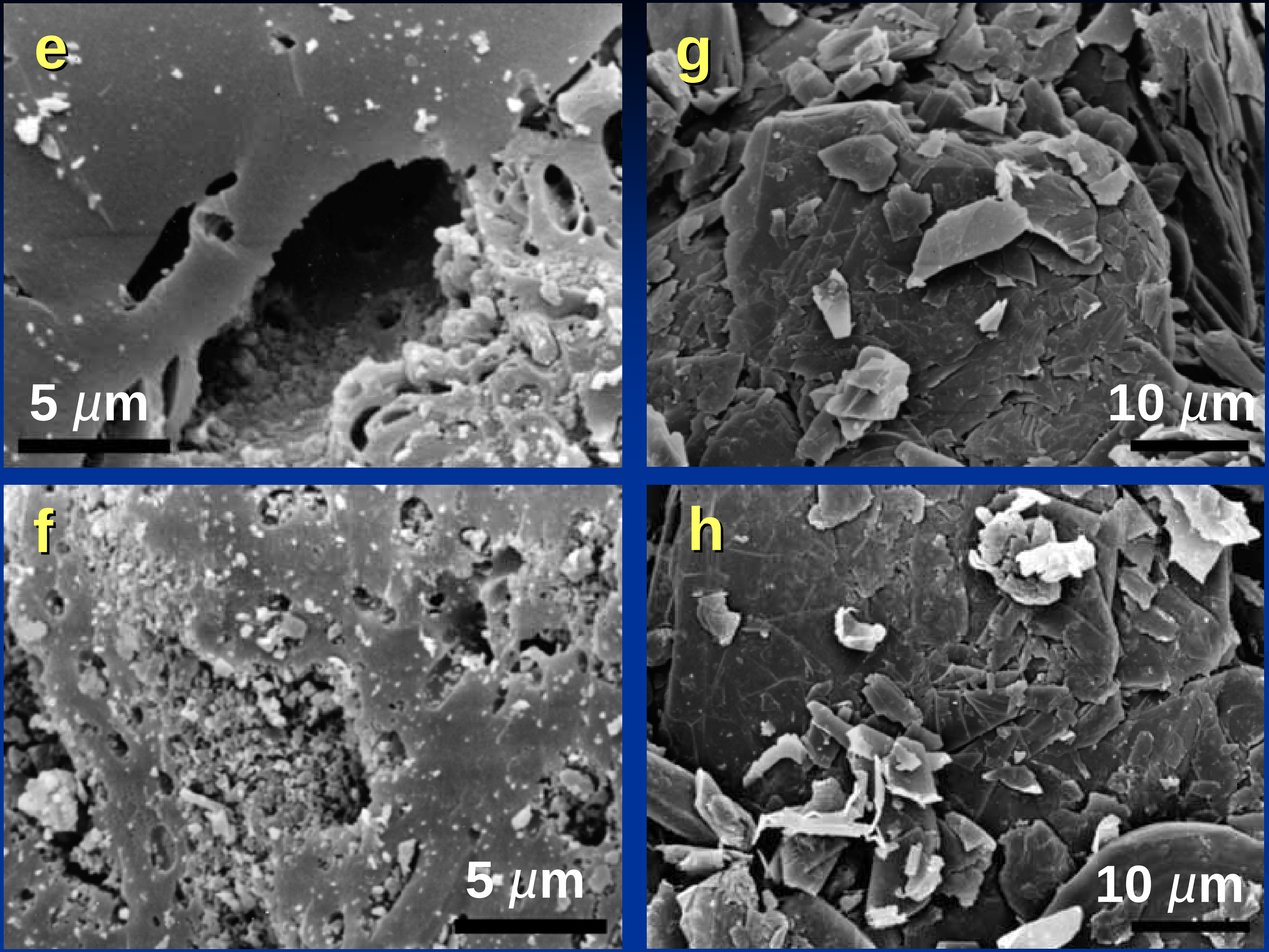
Results



Weight change of the samples by ozone treatment



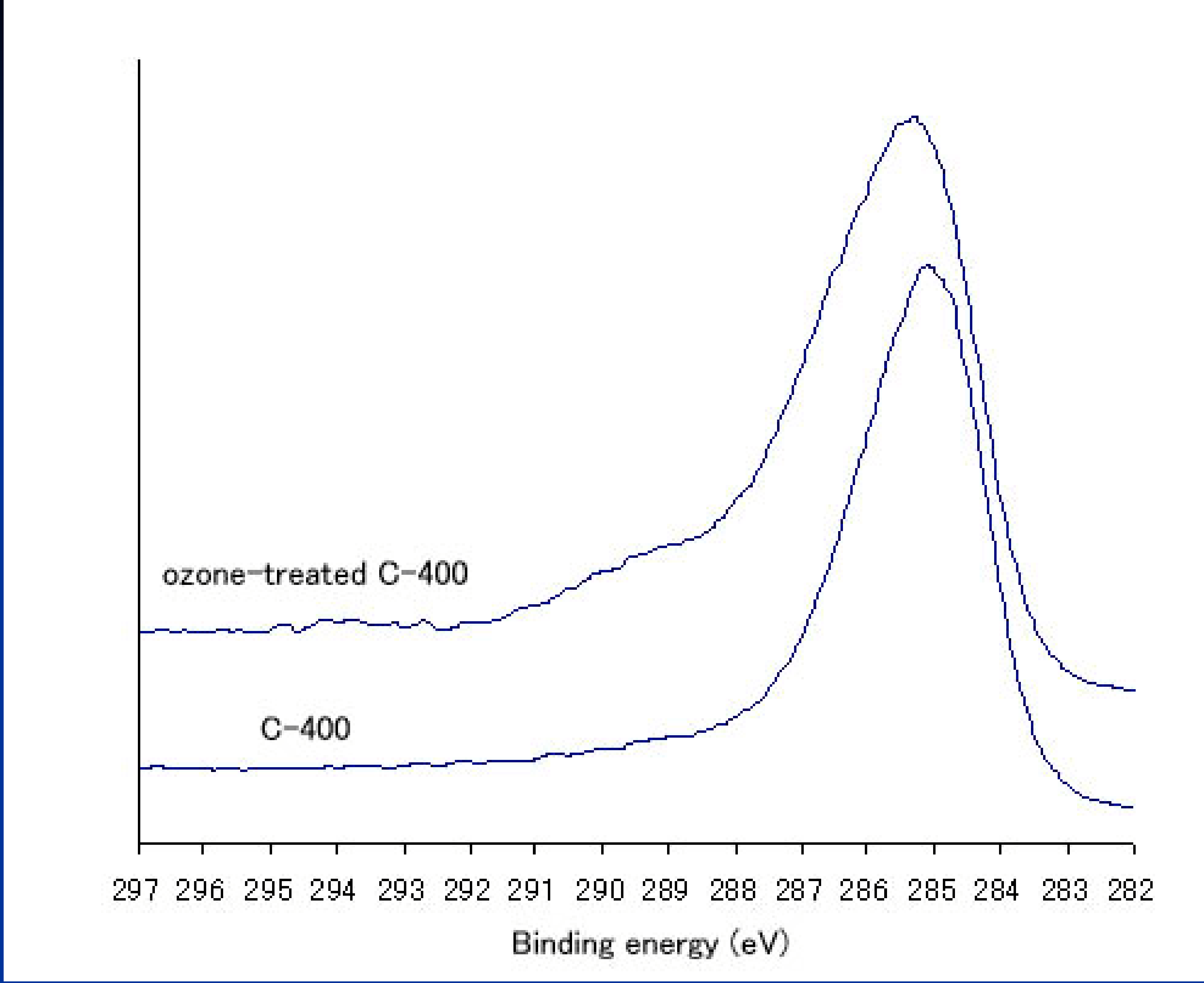
SEM. **a** C-1000 untreated, **b** C-1000 treated with ozone
c C-400 untreated, **d** C-400 treated with ozone



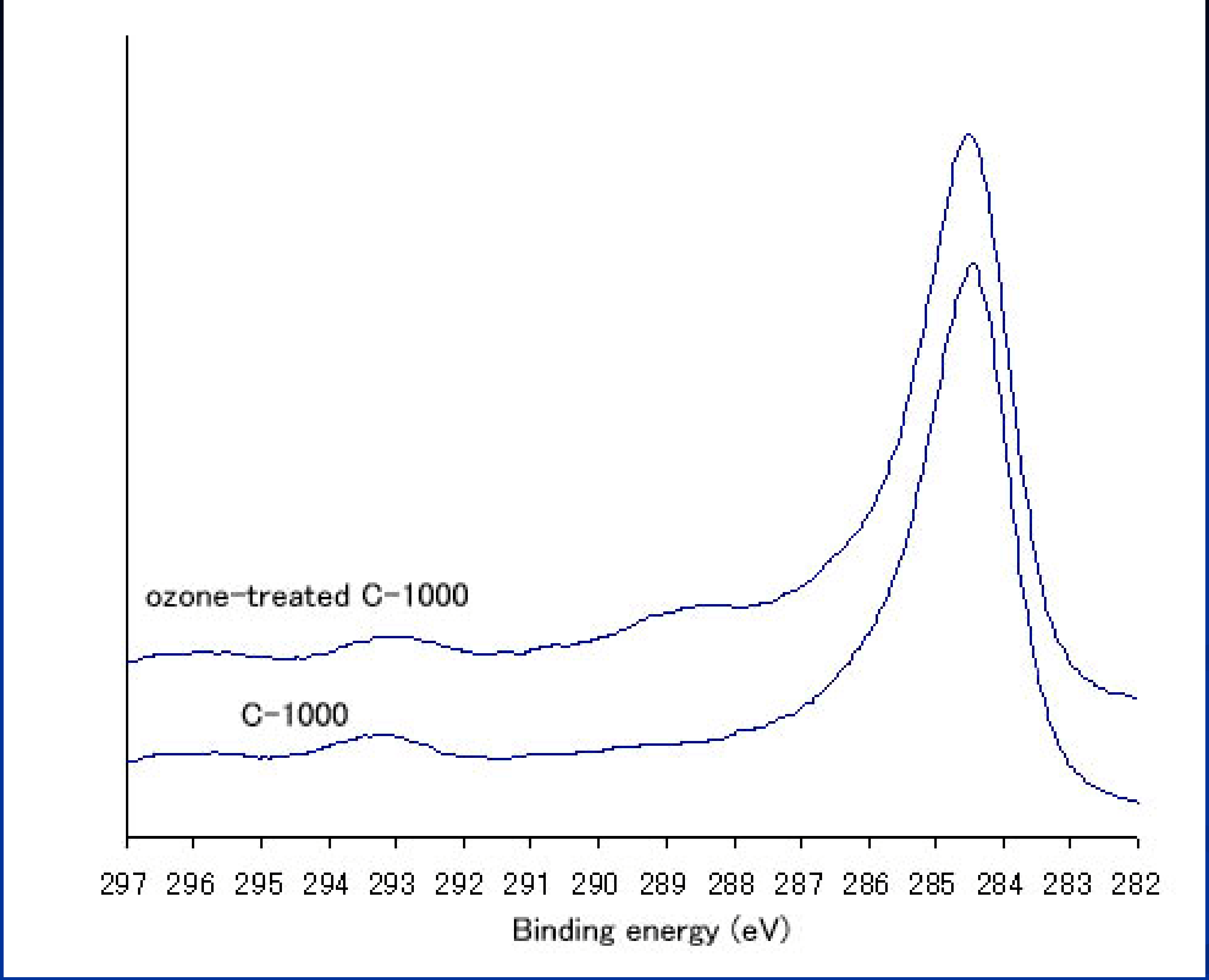
SEM. **e** AC untreated, **f** AC treated with ozone
g GR untreated, **h** GR treated with ozone

Contents of carbon, hydrogen, and oxygen in the untreated samples

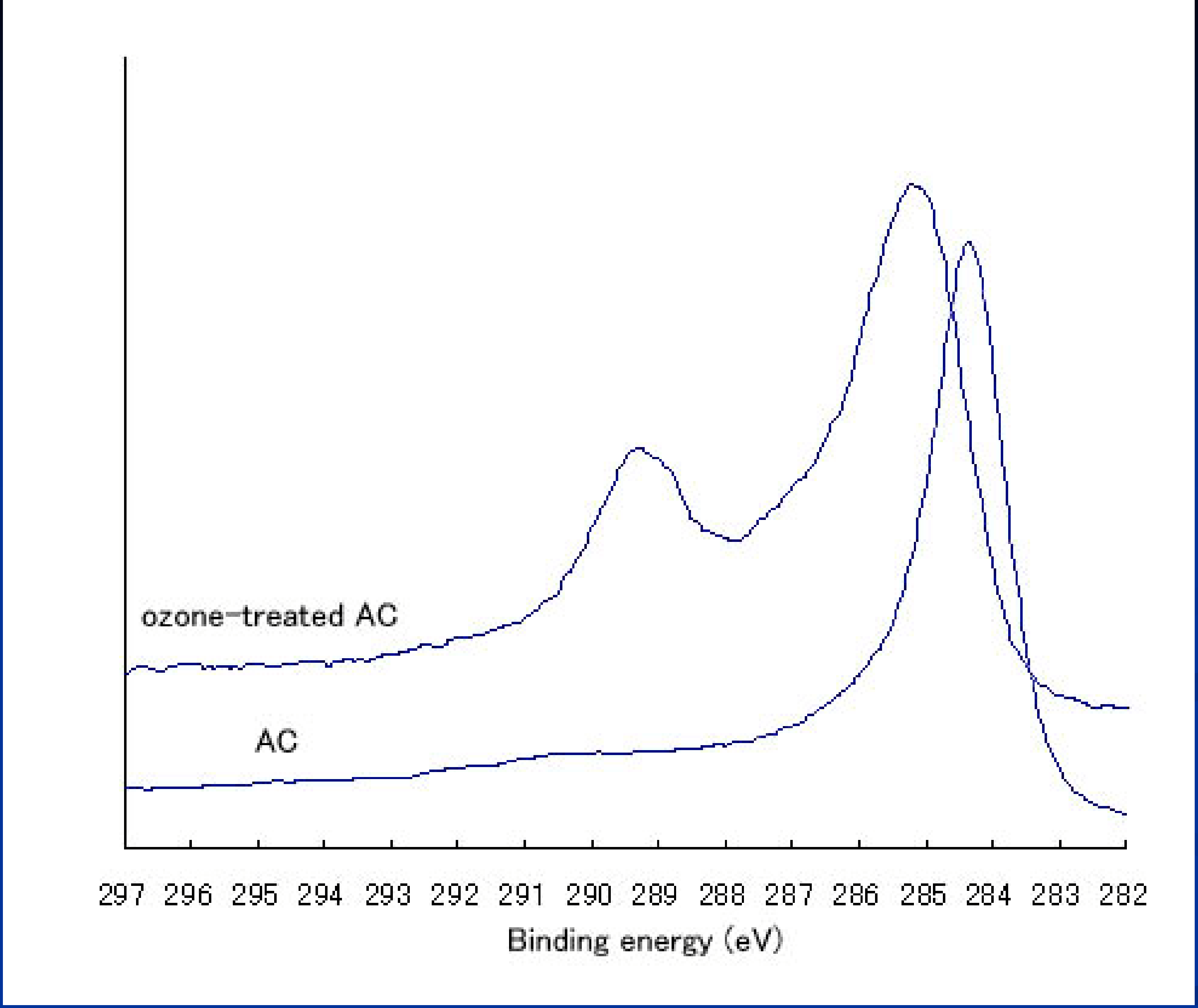
Sample	C	H	O
C-400	84.3	2.91	5.88
C-1000	94.8	0.25	1.03
AC	94.3	0.24	1.64
GR	95.2	< 0.1	0.26



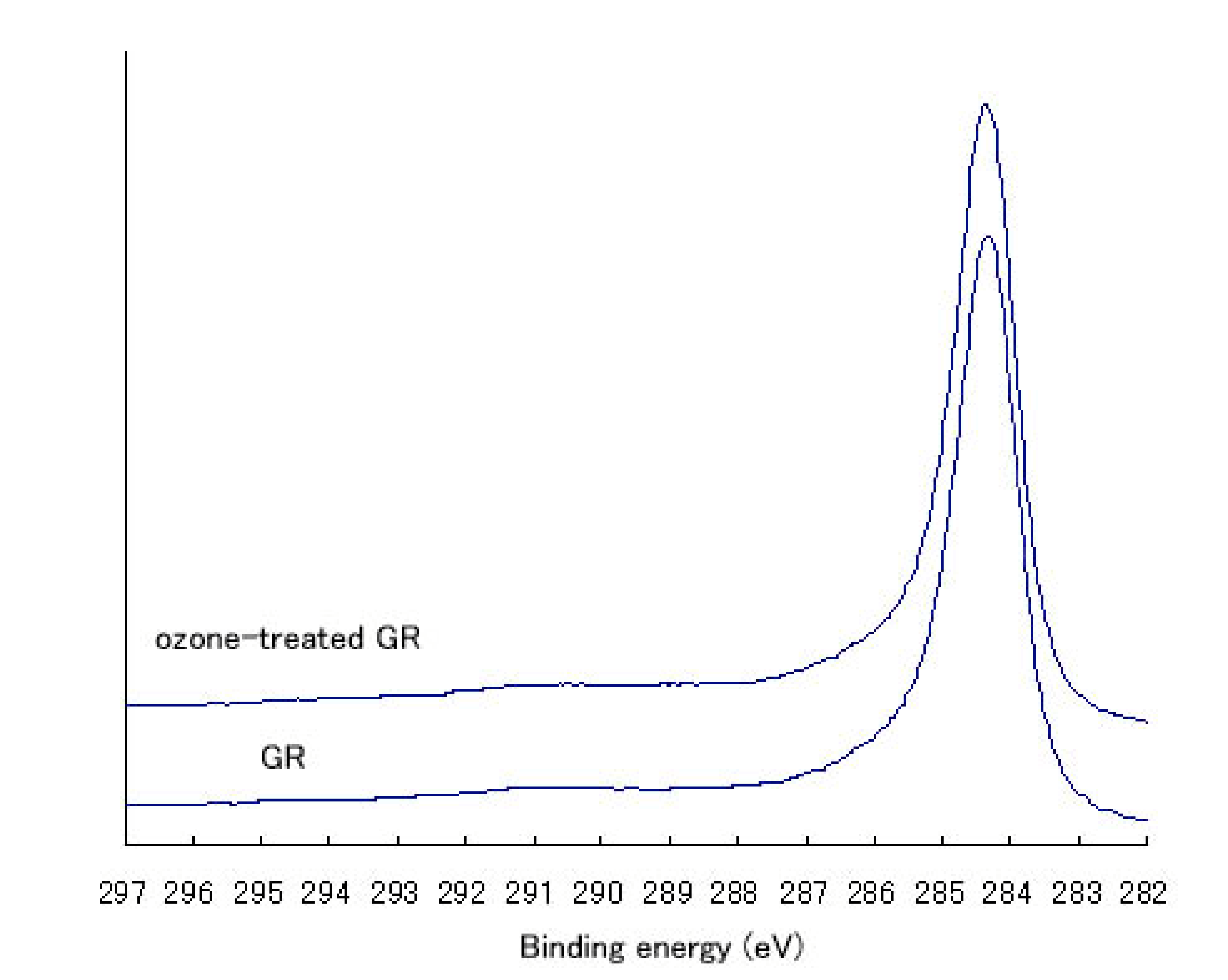
X-ray photoelectron spectra of
C-400 untreated and C-400 treated with ozone



X-ray photoelectron spectra of
C-1000 untreated and C-1000 treated with ozone



X-ray photoelectron spectra of
AC untreated and AC treated with ozone



X-ray photoelectron spectra of
GR untreated and GR treated with ozone

Rate constant for the weight decrease

$$\alpha = -\ln (W_t / W_0) / t$$

where α : rate constant (min^{-1})

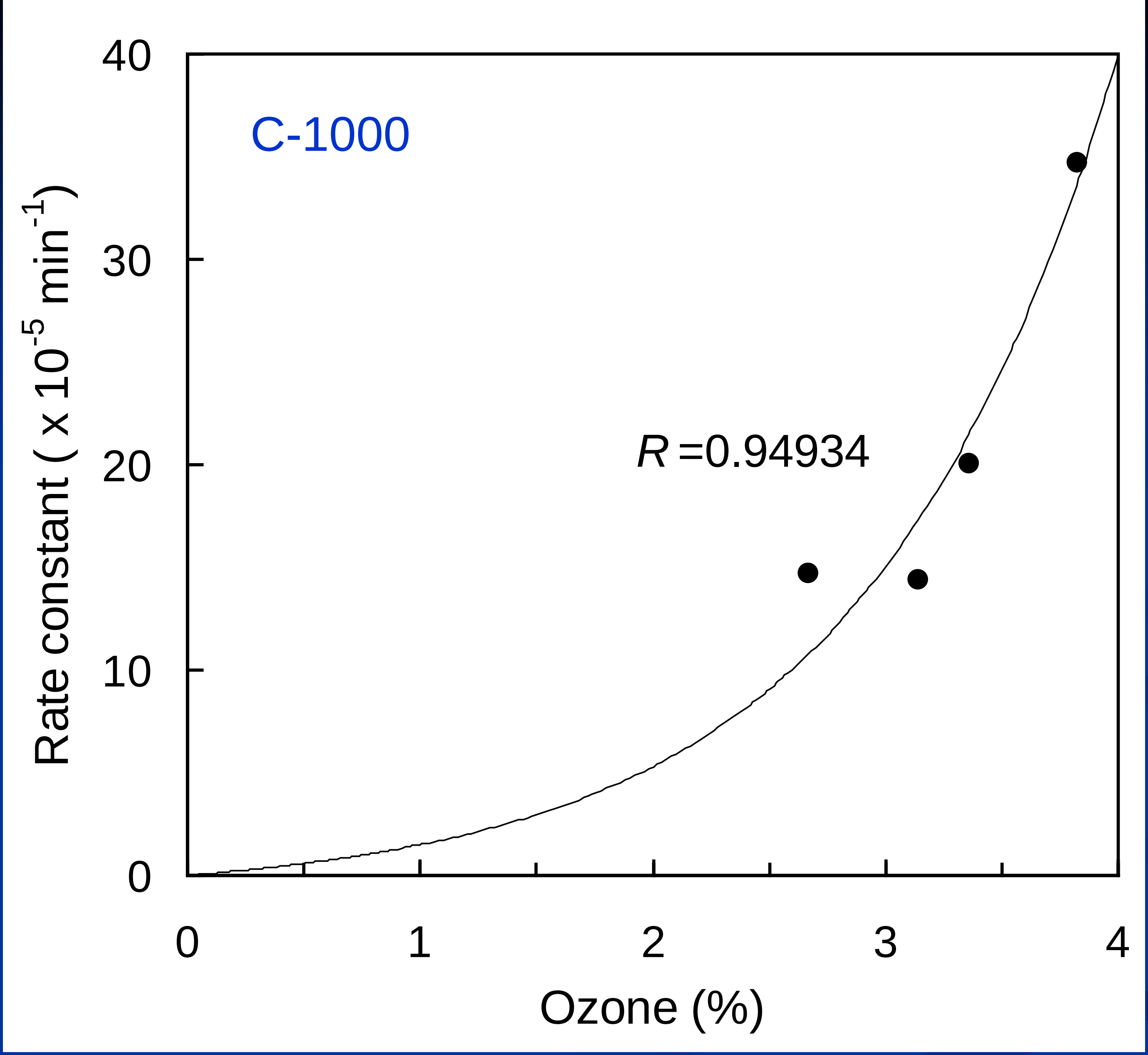
t : treatment time by ozone (min)

W_t : weight of the sample after treatment by ozone for t (min)

W_0 : weight of the sample before treatment by ozone

Rate constants (x 10^{-5}/min) of the weight decrease at each ozone concentration

Ozone concentration (*v*/*v* %)	C-1000	AC	C-400	GR
8.46	—	—	0.00	—
8.13	—	—	—	0.00
7.07	—	503	—	—
4.94	—	300	—	—
3.82	34.7	—	—	—
3.36	20.1	—	—	—
3.14	14.4	—	—	—
2.89	—	101	—	—
2.67	14.7	—	—	—



Plot of the rate constants vs. the ozone concentrations

Resulting equation of the exponential curve for C-1000

$$\alpha = 0.95857 \times 10^{-5} \times (\exp(C \times 0.93838) - 1)$$

where α : rate constant (min^{-1})

C : ozone concentration (%)

Rate constants of the weight decrease of C-1000 and AC and the estimated half-life at 29 ppb ozone

Sample	Rate constant (min^{-1})	Half-life (years)
C-1000	2.61×10^{-11}	5.1×10^{4}
AC	9.53×10^{-10}	1.4×10^{3}

Conclusions

- The weight of C-1000 and AC was significantly decreased by ozone treatment.

2. No decrease was observed in C-400 and GR.

3. Change of the surface morphology was observed in the ozone-treated C-1000 and AC.

4. Amorphous carbon structure of C-400 was stable with ozone.

5. The half-life of C-1000 with ozone in air was estimated to be 5.1×10^4 years.

6. The half-life of C-400 is suggested to be of geological length.

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