Effect of solvent treatment of rice straw

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Abstract:
The fractionation method was reported as solvent treatment of coal. In these days, the application of this method applied to biomass waste like rice straw. In the country where the amount of rice production is high, for example Thailand, it is important to mine rice straw. Therefore the solvent treatment of rice straw is hoped to improve it to energy resources and carbon materials. We examined solvent treatment of two type rice straw. One is from Thailand (RS-T) and another is from Japan (RS-J). In solvent treatment, we produced three solid components, Residue, Deposit and Solvent. Residue is insoluble component at 350°C and separated filtration. Deposit is insoluble component at room temperature in filtrate after treatment at 350°C and separated filtration after cooled down. Soluble is soluble component at room temperature and produced by removing solvent from filtrate by distillation. We evaluated the yields of these components and properties.

1. Introduction

We have been developing Hyper-coal (HPC) which is produced by thermal extraction in aromatic solvent such as 1-methylnaphtalene (solvent treatment) and separated from insoluble component (Okuyama et al., 2004*)*. Because of these treatments, the feathers of HPC are low ash concentration, low H_2O concentration, and excellent thermo-plasticity. HPC is hoped to be various carbon materials and used to coking additive for coke making. HPC is able to be produced by steaming coal, therefor HPC is seems to be renewable resource. The fractionation method is also solvent treatment and we can fractionate more components by the method (Ashida et al., 2008 and Ashida et al., 2009*)*. Biomass waste is focused on the material that is treated in solvent recently. In previous research, various biomass wastes were treated in solvent and the properties of productions were evaluated (Wannapeera et al., 2012*)*. In this study, we examined the two types of rice straw (RS), which were from Thailand (RS-T) and Japan (RS-J).

2. Experiment

Rice straw was treated as solvent treatment method by using 10L autoclave (Fig.1) *(*Wannapeera et al., 2012*)*. Feedstock and solvent were mixed and heated. The slurry was treated at 350°C for 60min. After treatment the slurry was filtered and separated insoluble component that is Residue. The filtrate was cool down to room temperature and filtrated again to separate from insoluble component that was soluble at 350°C (Deposit). The filtrate at r.t. was distillated to remove solvent at ATM and soluble component was acquired as solid (Soluble). The products were dried at 150°C under vacuum.
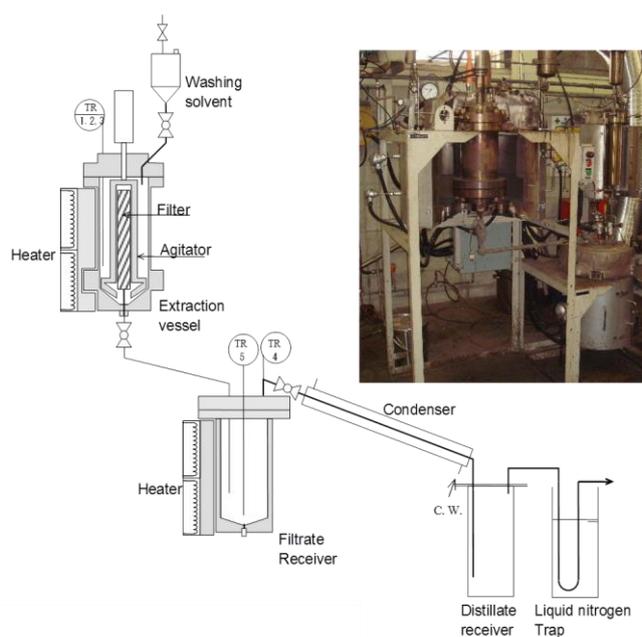

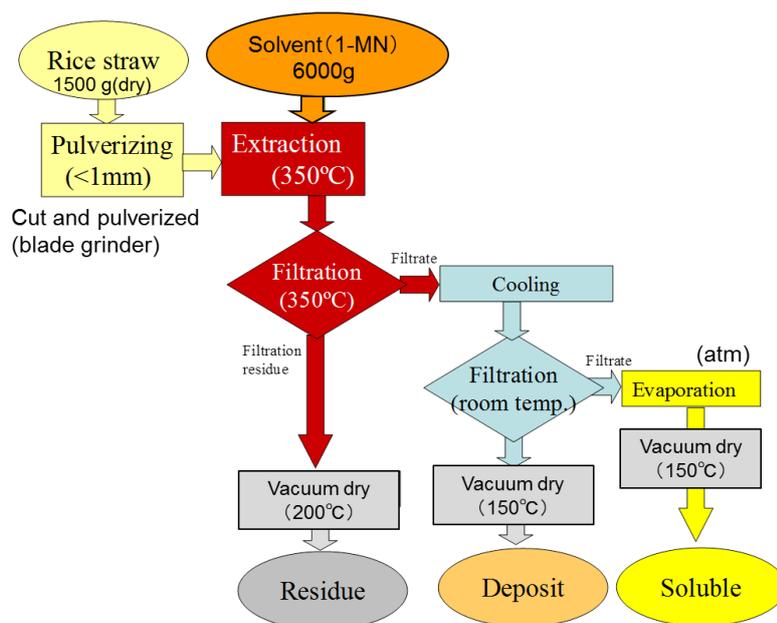**Fig.1** Schematic and picture of 10L autoclave.

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Fig. 2 Scheme of experimental procedure.

3. Materials

We used two types rice straw (RS). One is from Thailand (RS-T) and another is from Japan (RS-J). These properties show table 1. The treatment Solvent was mixture of 1-methylnaphtalene and 2-methylnaphthalene.

Table 1 the properties of feedstocks

Sample	Proximate analysis		Ultimate analysis					H/C	O/C
	Ash [wt% dry]	Vm [% daf]	C [% daf]	H [% daf]	N [% daf]	S [% daf]	O diff [% daf]		
RS-T	15.3	78.3	47.5	6.3	0.9	0.1	45.2	1.60	0.71
RS-J2	10.9	79.5	46.9	6.5	0.5	0.3	45.8	1.66	0.73

4. Results

The yields of each RS and properties of these components show table 2. Residue yield of RS-T was 15.7 wt% daf that is lower than that of RS-J, 20.1 wt% daf. However, Deposit yield was and Soluble yield were almost same. Deposit yield of RS-T was 2.6 wt% daf and that of RS-J was 1.7 wt% daf. Soluble yield of RS-T and RS-J is 17.3 wt% daf. The ash concentration of Residue was 54.1 wt% dry that was higher than that of RS-J, 37.4wt% dry. The atomic ratios of H/C of Residue were 0.84 (RS-T) and 0.80 (RS-J), and that of Deposit were 0.80 (RS-T) and 0.84 (RS-J). In case of Soluble, The atomic ratios of H/C was nearly 1.00, these were 0.97 (RS-T) and 0.96 (RS-J). The atomic ratios of O/C of these products were much lower than that of feedstock. The atomic ratio of RS-T was 0.71, however those of Residue, Deposit and Soluble were 0.18, 0.08 and 0.07 respectively. That of RS-J was 0.73, those of Residue, Deposit and Soluble were 0.08, 0.10 and 0.05.

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Table 2 Product yields and properties

| Sample | Sample | Yield [wt% daf] | Proximate analysis | | Ultimate analysis | | | | | H/C | O/C |
			Ash [wt% dry]	Vm [% daf]	C [% daf]	H [% daf]	N [% daf]	S [% daf]	O diff [% daf]		
RS-T	Residue	15.7	54.1	34.9	74.4	5.2	2.0	18.2	18.2	0.84	0.18
	Deposit	26	1.6	33.4	83.9	5.6	1.6	8.8	8.8	0.80	0.08
	Soluble	17.3	0.1	66.1	83.6	6.7	1.3	8.1	8.1	0.97	0.07
RS-J2	Residue	20.1	37.4	39.7	83.9	5.6	0.9	9.4	9.4	0.80	0.08
	Deposit	1.7	1.3	41.2	81.7	5.7	1.1	11.3	11.3	0.84	0.10
	Soluble	17.3	0.1	73.0	86.6	6.9	0.8	5.4	5.4	0.96	0.05

5. Discussion

The yields of products from RS-T and RS-J were comparatively approximate. Especially, the yield of Soluble which is the most important product was same. It seems that the production area of rice straw doesn't impact the yield of productions. However, the ash concentrations of rice straw are different, that influence the ash concentration of Residue. In this study, the concentration of RS-T was higher than that of RS-J and Residue yield of RS-T was lower than that of RS-J, the concentration of Residue of RS-T was much higher than that of RS-J.

Next, the elemental yields are considered. The carbon base yield shows Fig.2. The total carbon base yield of RS-T and RS-J were approximately 60% and 70% respectively. This means that carbon in feedstock remains in solid productions comparatively. The carbon base yield of Residue of RS-T was 11.5% lower than that of RS-J. The Residue yield of RS-T was 4.7wt% daf lower than that of RS-J and carbon concentration was also 9.5%daf lower than that of RS-J. That's why the carbon base yields were difference. The sum of carbon base yields of Deposit and Soluble of RS-T and RS-J were same as 35%. It is thought that the components which are dissolved at 350°C are similar. The hydrogen base yield shows Fig.3. The total hydrogen base yield of RS-T and RS-J were approximately 35% and 40% respectively. This means that more half hydrogen in feedstock doesn't remind in solid productions. It seems to converse H_2O. The deference between RS-T and RS-J is due to the Residue yield difference. The oxygen base yield shows Fig.4. The total oxygen base yields of RS-T and RS-J were lower 10%. This means that almost oxygen in feedstock doesn't remain in solid productions. It is thought to converse CO_2.

The total yields of solid productions were approximately 35 wt% daf and 40wt% daf, RS-T and RS-J respectively. However, the carbon base yields were comparatively high, 60-70%. The yields of solid production are due to oxygen reduction. It is not only remain of carbon in solid productions but also removing oxygen.
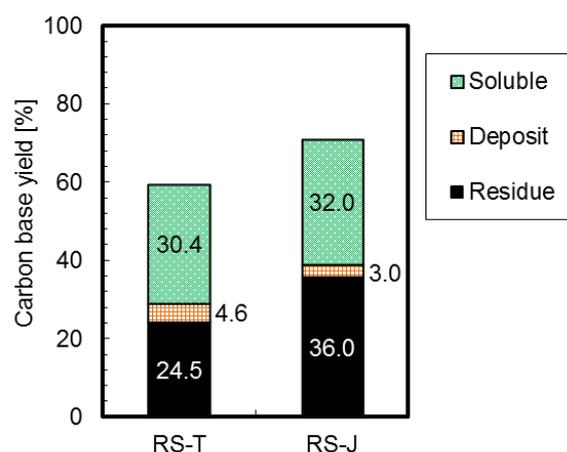

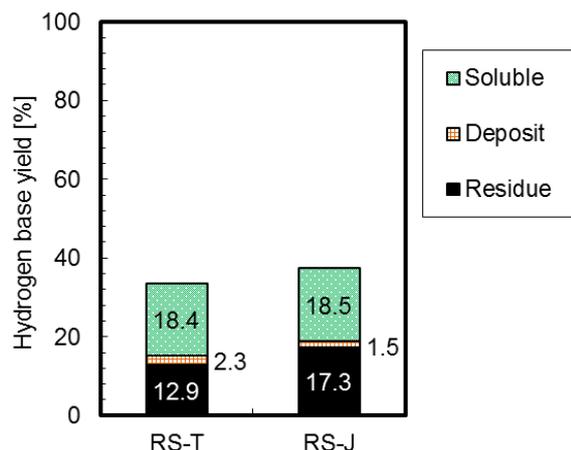**Fig.3** Carbon base yield in solid productions of RS-T and RS-J.

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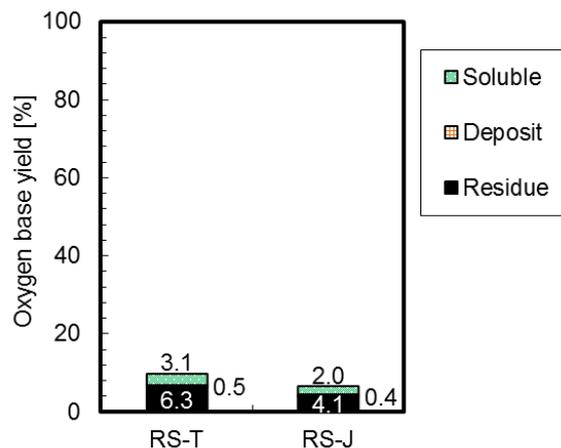**Fig.4** Hydrogen base yield in solid productions of RS-T and RS-J.

Fig.5 Oxygen base yield in solid productions of RS-T and RS-J.

6. Conclusion

We examined solvent treatment of two type rice straw. The yields of solid productions were almost same regardless of rice straw. Carbon tended to remain in solid productions, the total carbon base yield of products was 60-70%. However, almost oxygen in feedstock was removed and the total oxygen base yield of solid products was lower 10%. This solvent treatment becomes clear that not only removing oxygen efficiently but also remaining carbon comparatively.

7. Acknowledgement

8. References

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