Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Roles of hydrothermal-alkali treatment in tanning sludge reduction: Rheological properties and sludge reduction mechanism analysis

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S.I. 1 Properties of raw sludge

Table S1 Properties of raw sludge

Materials	Indicators		Content
Raw sludge	Separated Supernatant	Polysaccharide (mg/L)	23.74 ± 10
		Protein (mg/L)	46.26 ± 10
		NH_3-N (mg/L)	1.62 ± 0.5
		TP (mg/L)	0.10 ± 0.02
		COD (mg/L)	50.59 ± 20
		pH	6.5 ± 0.1
	Dried Solid	TSS (g/L)	21.10 ± 10
		OC* (%)	32.48 ± 5
		MC** (%)	67.52 ± 5

*mass ratio of organic content; **mass ratio of mineral content

S.I. 2 Mechanical shear

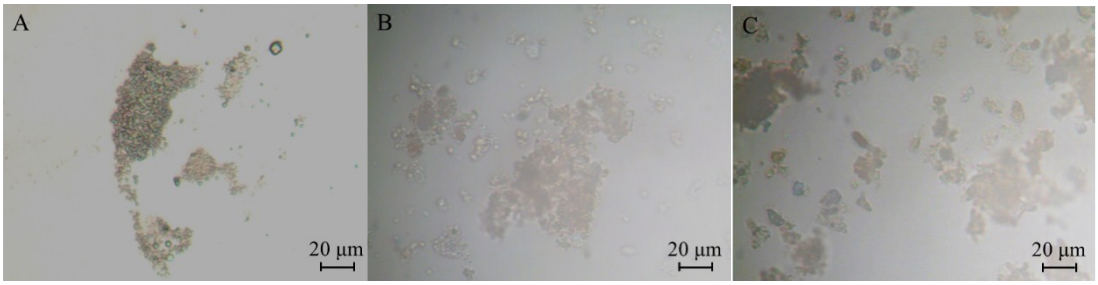
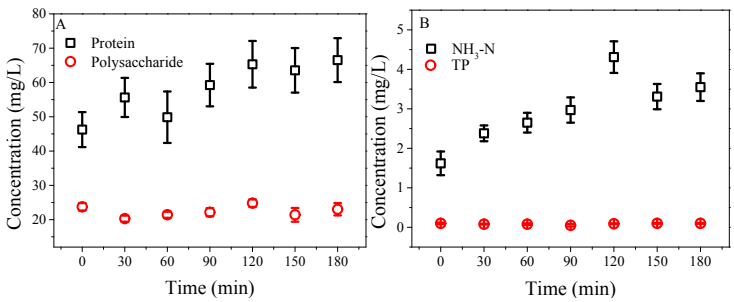


Fig.S1 Microscope pictures of raw sludge (A), sludge after mechanical shearing treatment (B) and sludge after hydrothermal-alkali treatment (C) in solution.

The morphology of sludge solids in solution before and after treatment were characterized by microscope (**Fig.S1**). Comparing with the morphology of sludge in **Fig.S1-A**, it can be seen that the sludge were crushed into small particles by mechanical shearing treatment (**Fig.S1-B**). However, the hydrothermal-alkaline treatment had slight effect on the particle size of sludge (**Fig.S1-C**).



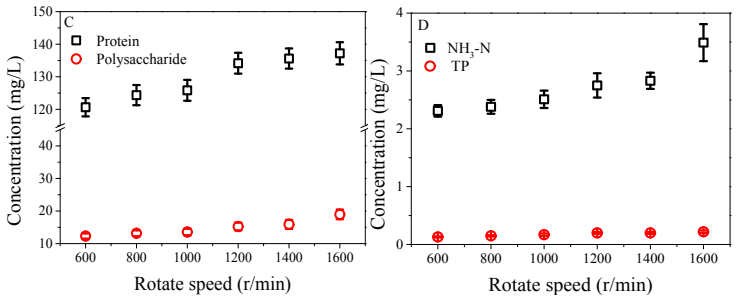


Fig.S2 Effects of mechanical shearing time (shearing rate is 600 rpm) (A, B) and shearing rate (shearing for 30 min) (C, D) at room temperature (20℃) on the soluble organics (protein, polysaccharide, NH_3-N and TP) in sludge supernatant.

The organics (protein, polysaccharide, NH_3-N and TP) in sludge supernatant under different mechanical shearing conditions were shown as **Fig.S2**. In **Fig.S2-A**, it can be seen that the protein concentration increased from 46.3 mg/L to 66.5 mg/L with increasing mechanical shearing time and reached a plateau at 120 min. The results were consistent with the improvement of NH_3-N concentrations (1.62 mg/L to 3.55 mg/L) in **Fig.2-B**. The mechanical shearing speed is a key factor influencing the sludge properties. The effect of mechanical shearing speed on the concentrations of organic matter in sludge supernatant were shown in **Fig.2 C-D**. The concentrations of protein and NH_3-N in sludge supernatant increased with the increasement of mechanical shearing speed. The concentration of NH_3-N and protein in sludge supernatant were 135.2 mg/L and 3.5 mg/L at 1600 rpm respectively, which were higher than their initial concentrations (120.1 mg/L and 2.3 mg/L). The results indicate that the mechanical shearing treatment can promote the dissolution of organic matters. However, for the polysaccharide and TP, the concentrations changed slightly, which can be attributed to the low contents in the raw sludge [6]. Besides, the morphology of sludge in solution was characterized by microscope in **Fig.S2**. Comparing with the raw sludge in **Fig.S2-A**, the sludge were broke down by mechanical shear (**Fig.S2-B**). But

according to related research, the break down for sludge structure is transitory and it will build-up at rest [9]. Hence, the further alkaline treatment for the sludge is necessary after mechanical shear.

S.I. 3 HAT treatment

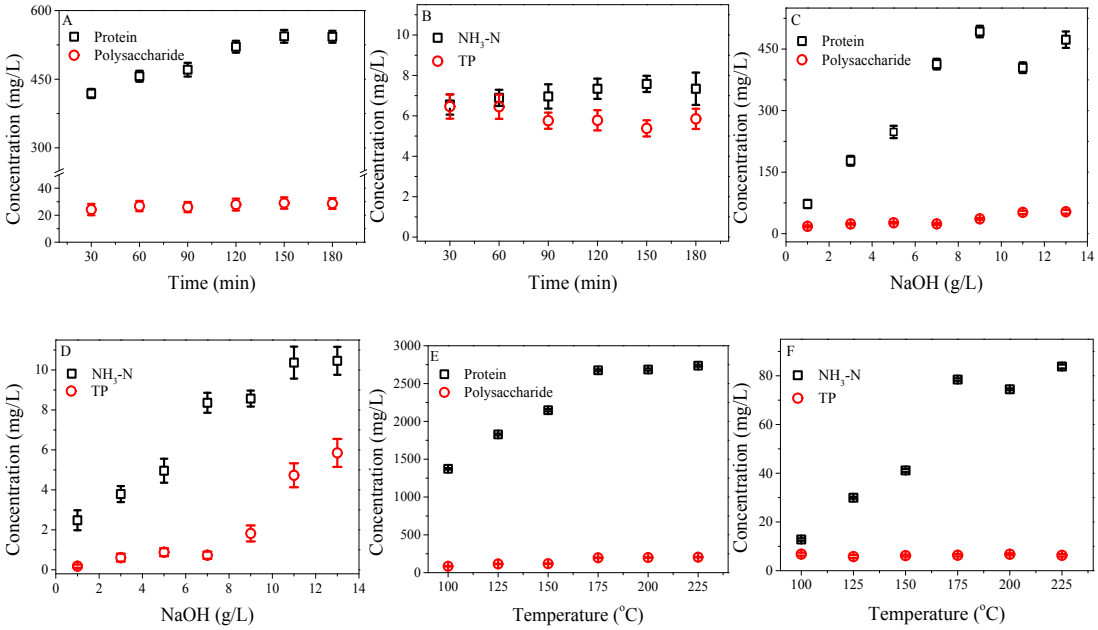


Fig.S3 Effects of the HAT with different treatment time (30-180 min), NaOH dosage (1-13 g/L) and temperature (100-225℃) on the soluble organics (protein, polysaccharide, NH_3-N and TP) in sludge supernatant with different conditions.

The contents of soluble organics in sludge supernatant after the HAT were shown as **Fig.S3**. In **Fig.S3 A-B**, the contents of protein and NH_3-N increased with the reaction time, and the curves reached a plateau (497.8 mg/L and 7.2 mg/L) at 120 min. With the variation of NaOH (1-13g/L), the protein, NH_3-N and TP increased from 72.3, 2.2 and 0.1 mg/L to 472.9, 4.5 and 0.7 mg/L, respectively (**Fig.S3 C-D).** The contents of soluble protein and NH_3-N increased in **Fig.S3 E-F**, and the curves reached the plateau at 175°C.

S.I. 4 Composition analysis for sludge

Table S2 Elemental composition of sludge

	C (%)	N (%)	H (%)	S (%)

RS	11.35	1.45	2.24	4.82
HS	10.91	0.29	1.69	0.46
SS	27.63	3.45	3.59	8.43