Electronic Supplementary Material (ESI) for RSC Advances.

Table S1 Contents of some common metals in the granules before and after Fe(III) modification, determined by ICP-AES from digested and acid-dissolved granules.

	K	**Na**	**Ca**	**Mg**	**Fe**	**Fe content (mg mg^{-1})**	**reference**
OAGS-B	0.26%	0.07%	8.8%	0.74%	0.11%	0.0011	**1**
Fe-MAGS-B	0.003%	0.002%	0.02%	0.004%	5.9%	0.059	
OAGS-F	2.5%	0.09%	0.05%	0.23%	0.06%	0.0006	**2**
Fe-MAGS-F	0.04%	0.01%	0.01%	0.004%	1.6%	0.016	

Table S2 Comparison of two kinetic models at different Sb(V) initial concentrations (T: 35 °C, shake speed: 175 rpm, pH: 3.4, biomass dosage: 0.4 g L^{-1}).

MAGS	C_0 (mg L^{-1})	$q_{e,exp}$ (mg g^{-1})	Pseudo-first-order*			Pseudo-second-order**					Reference
			$q_{e,calc}$ (mg g^{-1})	$k_1\times10^{-2}$ (min^{-1})	r^2	$q_{e,calc}$ (mg g^{-1})	$k_2\times10^{-3}$ (g $mg^{-1}min^{-1}$)	h (mg $g^{-1}min^{-1}$)	$t_{1/2}$ (min)	r^2	
MAGS-F	20	33.9	15.9	2.3	0.909	35.7	4.75	6.1	5.9	0.999	Present study
	60	85.9	32.3	1.9	0.869	90.9	2.28	18.8	4.8	0.999	
	100	130	54.8	1.8	0.900	142	1.11	22.4	6.3	0.999	
MAGS-B	20	36.6	23.9	1.7	0.902	38.5	1.67	2.5	15.6	0.999	**1**
	60	102	67.8	1.5	0.944	111	0.52	6.4	17.3	0.999	
	100	146	97.7	1.3	0.920	167	0.30	8.4	20	0.998	

* Model equation: $\ln(q_e-q_t) = \ln q_e - k_1 t$, where q_e (mg g^{-1}) and q_t (mg g^{-1}) represent the amounts of the Sb(V) absorbed at equilibrium and at time t (min), respectively, and k_1 is the rate constants (min^{-1}).[3]

** Model equation: $t/q_t = 1/k_2q_e^2 + t/q_e$, where k_2 is the rate constants (min^{-1}). The initial sorption rate can be calculated as $h=kq_e^2$, and half-adsorption time as $t_{1/2}=1/kq_e$.[4]

Table S3 Isotherm model parameters for the biosorption of Sb(V) onto the modified granules (T: 35 ^{o}C, shake speed: 175 rpm, pH: 3.4, biomass dosage: 1 g L^{-1}).

MAGS	Langmuir model*			Freundlich model**			reference
	q_m	b (L mg^{-1})	r^2	k_F (mg g^{-1})	n	r^2	
MAGS-B	125	0.056	0.987	27.1	3.9	0.963	**5**
MAGS-F	111	0.112	0.997	24.3	3.3	0.957	**2**

* Model equation: $C_e/q_e = C_e/q_m + 1/(bq_m)$, where C_e represents the Sb(V) equilibrium concentration (mg L^{-1}), q_e is the equilibrium adsorption quantity (mg g^{-1}), q_m is the maximum monolayer adsorption quantity (mg g^{-1}), and b is the Langmuir constant (L mg^{-1}).[6]

** Model equation: $\ln q_e = 1/n \ln C_e + \ln k_F$, where k_F is the Freundlich constant (mg g^{-1}), and $1/n$ is related to the adsorption intensity of the adsorbent.[7]

Table S4 Thermodynamic model parameters for the biosorption of Sb(V) onto the modified granules,* (pH: 3.4, shake speed: 175 rpm, biomass dosage: 0.4 g L^{-1}).

T (℃)	ΔG (kJ mol^{-1})		ΔH (kJ mol^{-1})		ΔS (J $mol^{-1}\cdot K^{-1}$)	
	MAGS-B**	**MAGS-F**	**MAGS-B**	**MAGS-F**	**MAGS-B**	**MAGS-F**
10	-4.87	-6.52	16.1	15.3	74.1	77.1
25	-5.98	-7.68				
35	-6.72	-8.45				
45	-7.46	-9.22				

*The thermodynamic parameters including entropy (ΔS), enthalpy(ΔH), and the Gibbs free energy (ΔG) obtained as: $\Delta G = -RT\ln K$, $K = q_e/C_e$, $\Delta G = \Delta H - T\Delta S$, where R represents the ideal gas constant, 8.314×10^{-3} kJ mol^{-1} K^{-1}, T is the absolute temperature (K), and the distribution coefficient is expressed as K, which is the ratio of equilibrium adsorption quantity to the equilibrium concentration of Sb(V).[8]

**The data of MAGS-B are cited from Wang et al.[5]

Table S5 A systematic comparison of various parameters between bacterial granules (BG) and fungal granules (FG).

Characteristics		Bacterial granules	Fungal granules
Formation process	**Difference in culture media**	KH_2PO_4 0.66 g L^{-1} peptone 0.4 g L^{-1} yeast extract 0.25 g L^{-1}	KH_2PO_4 0.20 g L^{-1} peptone 0.04 g L^{-1} yeast extract 0 g L^{-1}
	Carbon source	sodium acetate + sodium propionate	glucose
	Influent COD conc.	1000~3000 mg L^{-1}	1000 mg L^{-1}
	Settling time	30 to 1 min	5 min
	Culturing time	20 days	5 days
	pH change in one cycle	7 to 8.5	7 to 4.5
Original granules	**Size**	3-5 mm	1-7 mm
	Color	light yellow	white
	SVI	48 mL g^{-1}	74 mL g^{-1}
	Settling speed	5.6 cm s^{-1}	2.5 cm s^{-1}
	Moisture content	92%	93%
	Ash content	24%	5.2%
	Fe concentration	0.0011 mg mg^{-1}	0.0006 mg mg^{-1}
	Specific surface area	65.4 m^2 g^{-1}	9.1 m^2 g^{-1}
	Pore volume	0.196 mL g^{-1}	0.021 mL g^{-1}
	Pore size	12.38 nm	10.81 nm
	Cation adsorption	Bacterial better than fungal, pH 3.4~7.6 similar, 1.9/2.6 bad performance	
	Sb(V) adsorption	bad performance regardless of pH	
Modified granules	**Color**	brown	brown
	Fe concentration	0.059 mg mg^{-1}	0.016 mg mg^{-1}
	Specific surface area	8.52 m^2 g^{-1}	29.7 m^2 g^{-1}
	Pore volume	0.029 mL g^{-1}	0.054 mL g^{-1}
	Pore size	14.81 nm	6.97 nm
	Stability at high pH	poor	good
Sb(V) removal by modified granules	**Kinetic model**	Pseudo-second-order describes best	
	Initial rate (mg $g^{-1}min^{-1}$)	2.5~8.4	6.1~22
	Rate constant (g $mg^{-1}min^{-1}$)	0.0003~0.00167	0.00111~0.00475
	Half adsorption time	15.6~20 min	4.8~6.3 min
	Isotherm	Langmuir describes better	
	Maximum adsorption capacity	125 mg g^{-1}	111 mg g^{-1}
	Thermodynamics	Spontaneous adsorption （10~45℃）	
	ΔH	16.1 kJ mol^{-1}	15.3 kJ mol^{-1}
	ΔS	74.1 J $mol^{-1}·K^{-1}$	77.1 J $mol^{-1}·K^{-1}$

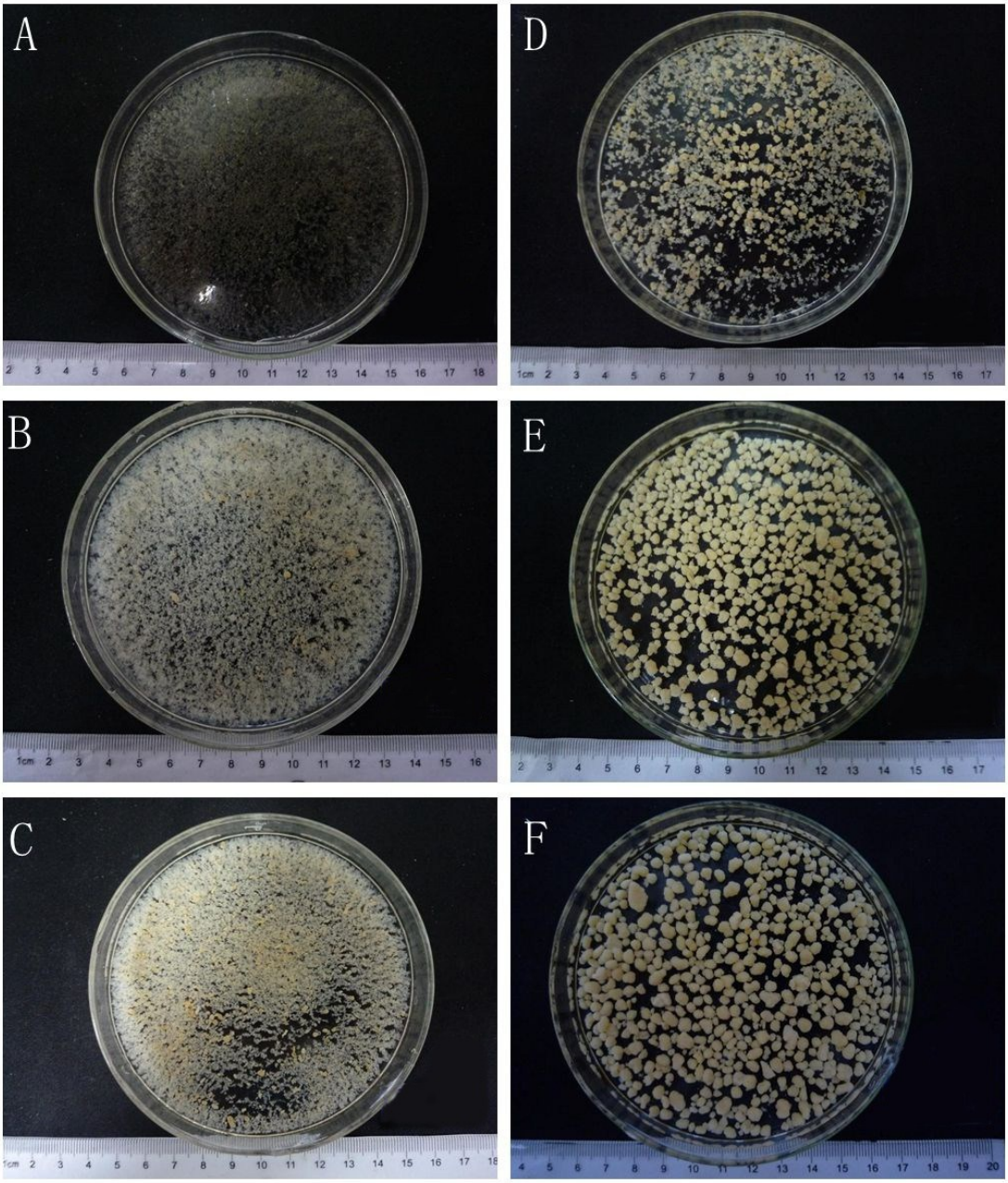

Fig. S1 Biomass morphology change during formation of bacterial granules. (A) day 1 (B) day 4 (C) day 6 (D) day11 (E) day18 (F) day20.

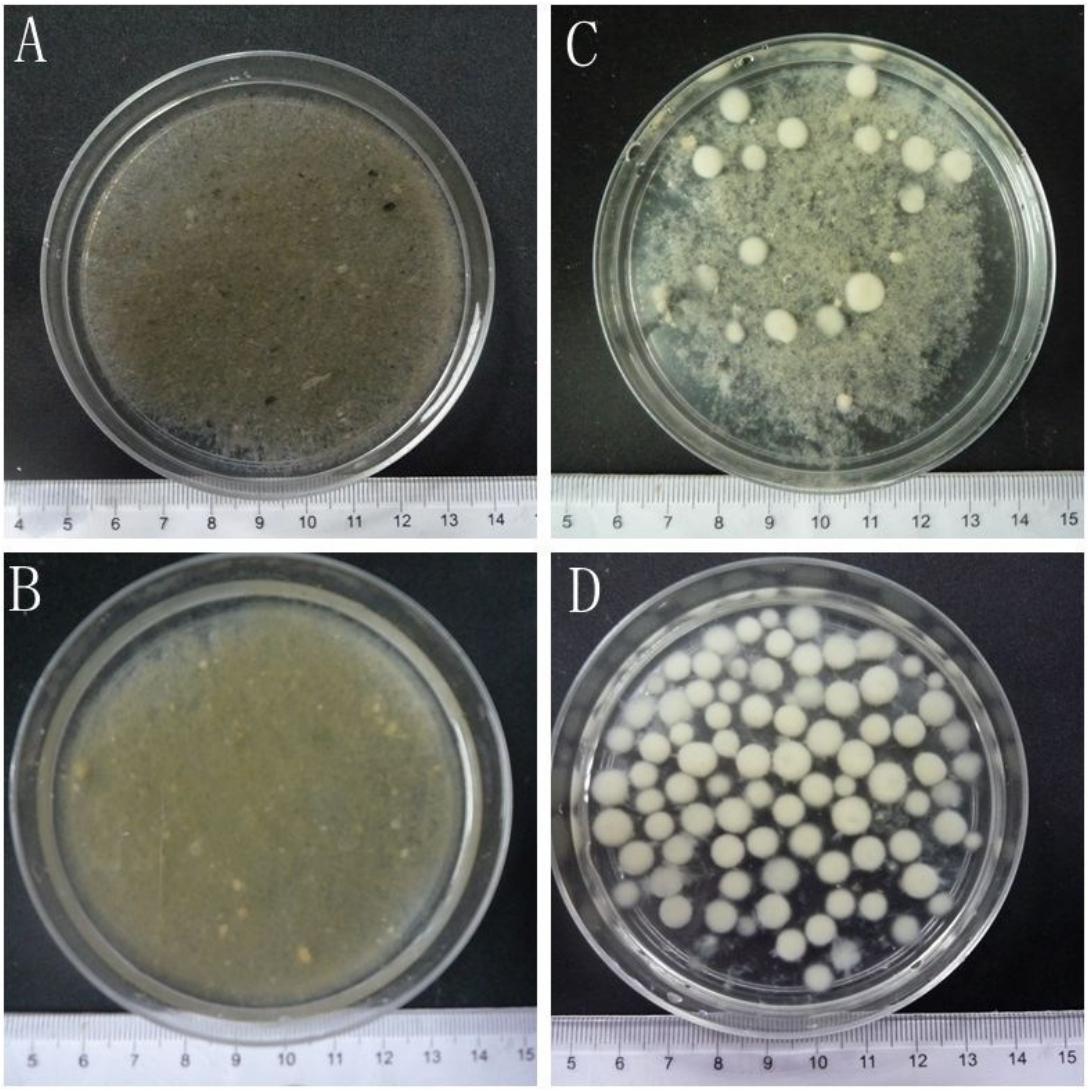

Fig. S2 Biomass morphology change during formation of fungal granules. (A) day 1 (B) day 2 (C) day 3(D) day 5.

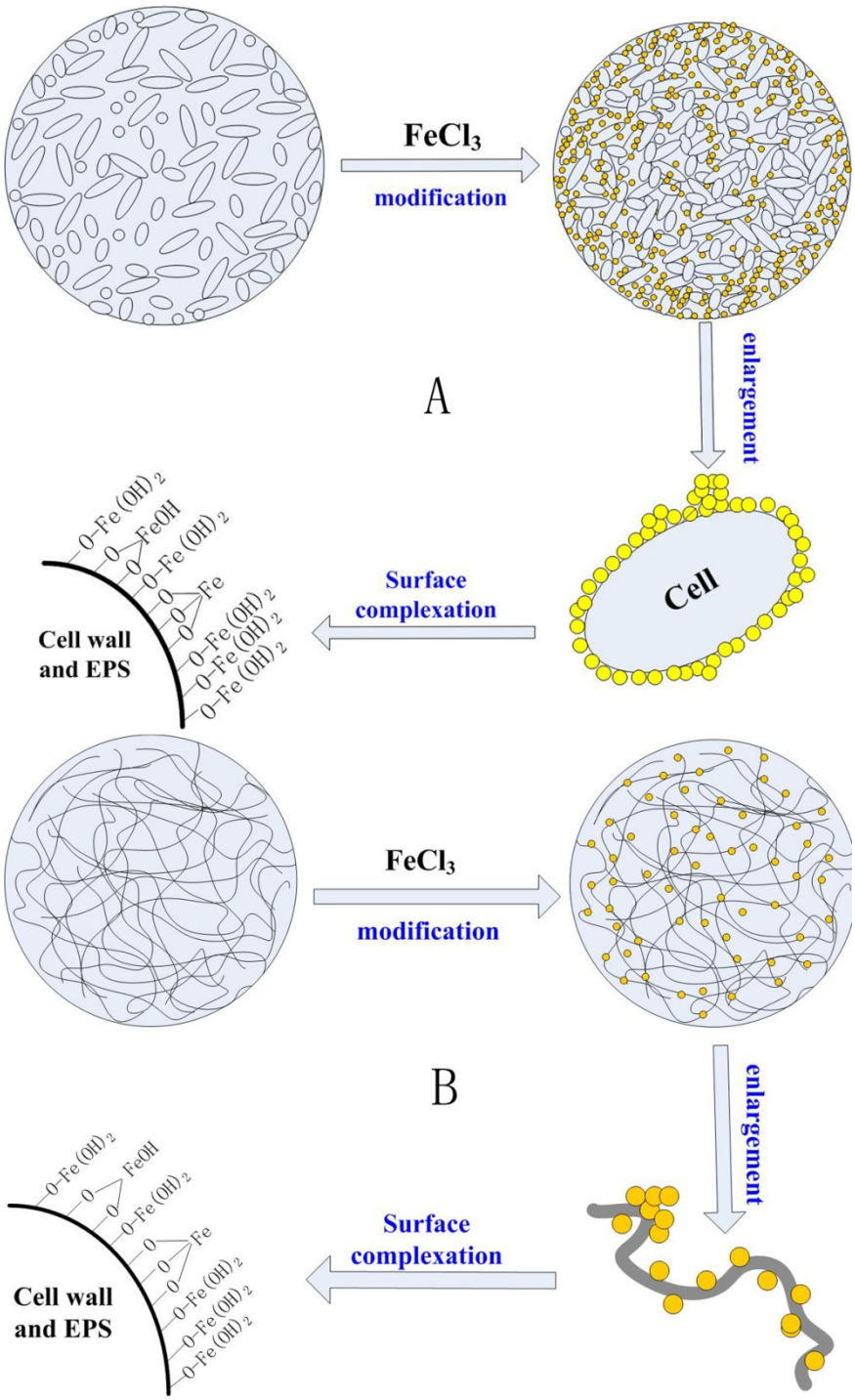

Fig. S3 Proposed mechanisms of Fe(III) modification on aerobic granules. (A) bacterial granules; (B) fungal granules.

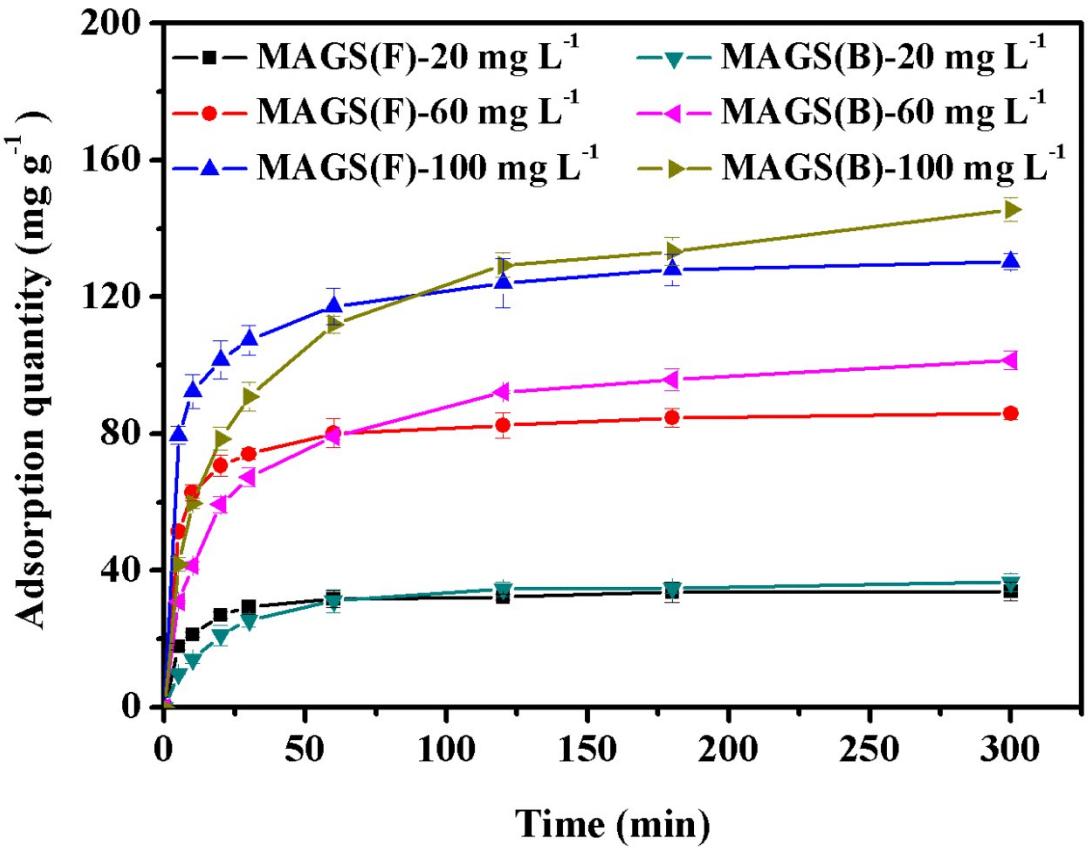

Fig. S4 Effect of initial concentrations and contact time on Sb(V) removal by modified granules, (T: 35 ^{0}C, shaking speed: 175 rpm, pH 3.4, biomass dosage: 0.4 g L^{-1}).

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