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Activated carbon from banana peel: an emerging biobased material for adsorption of diclofenac

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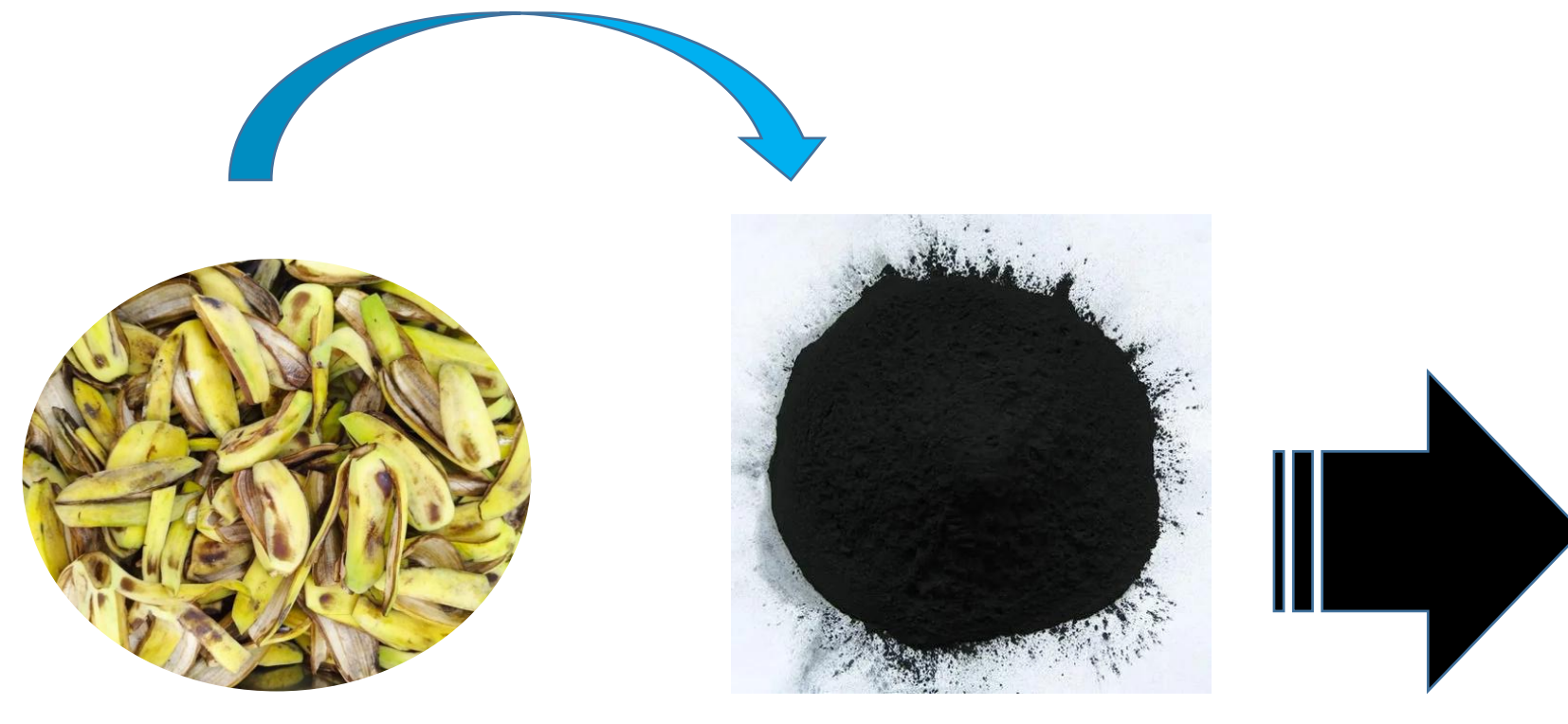
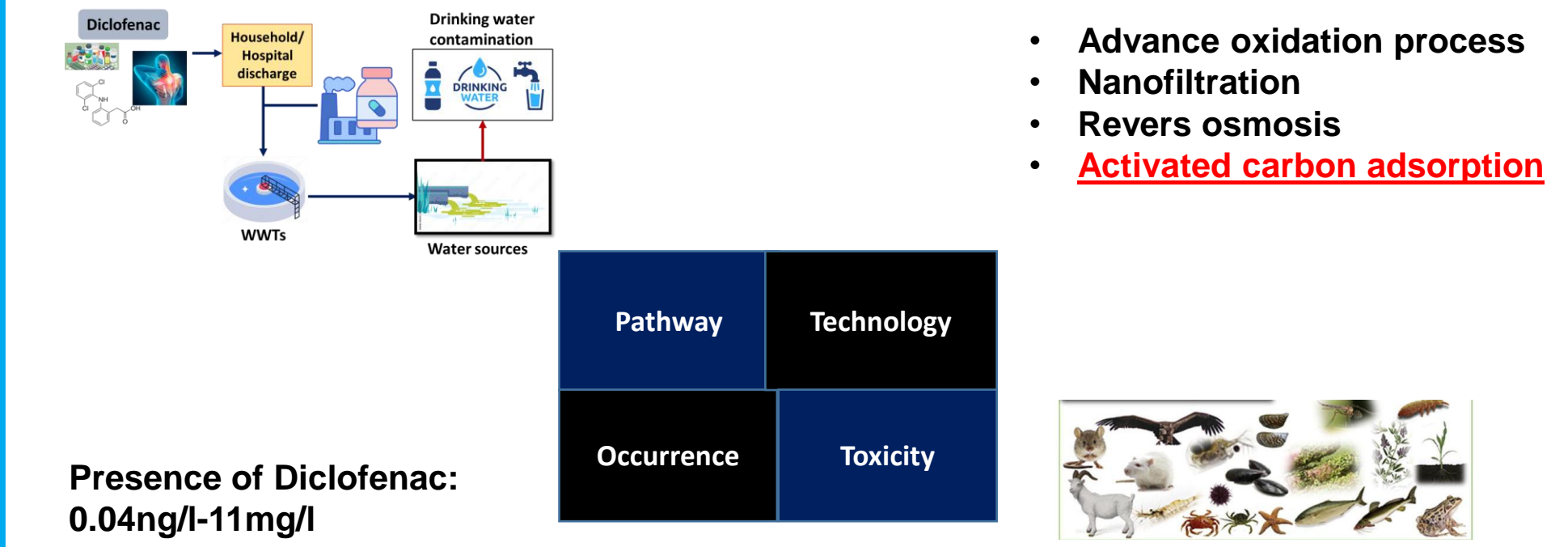
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INTRODUCTION

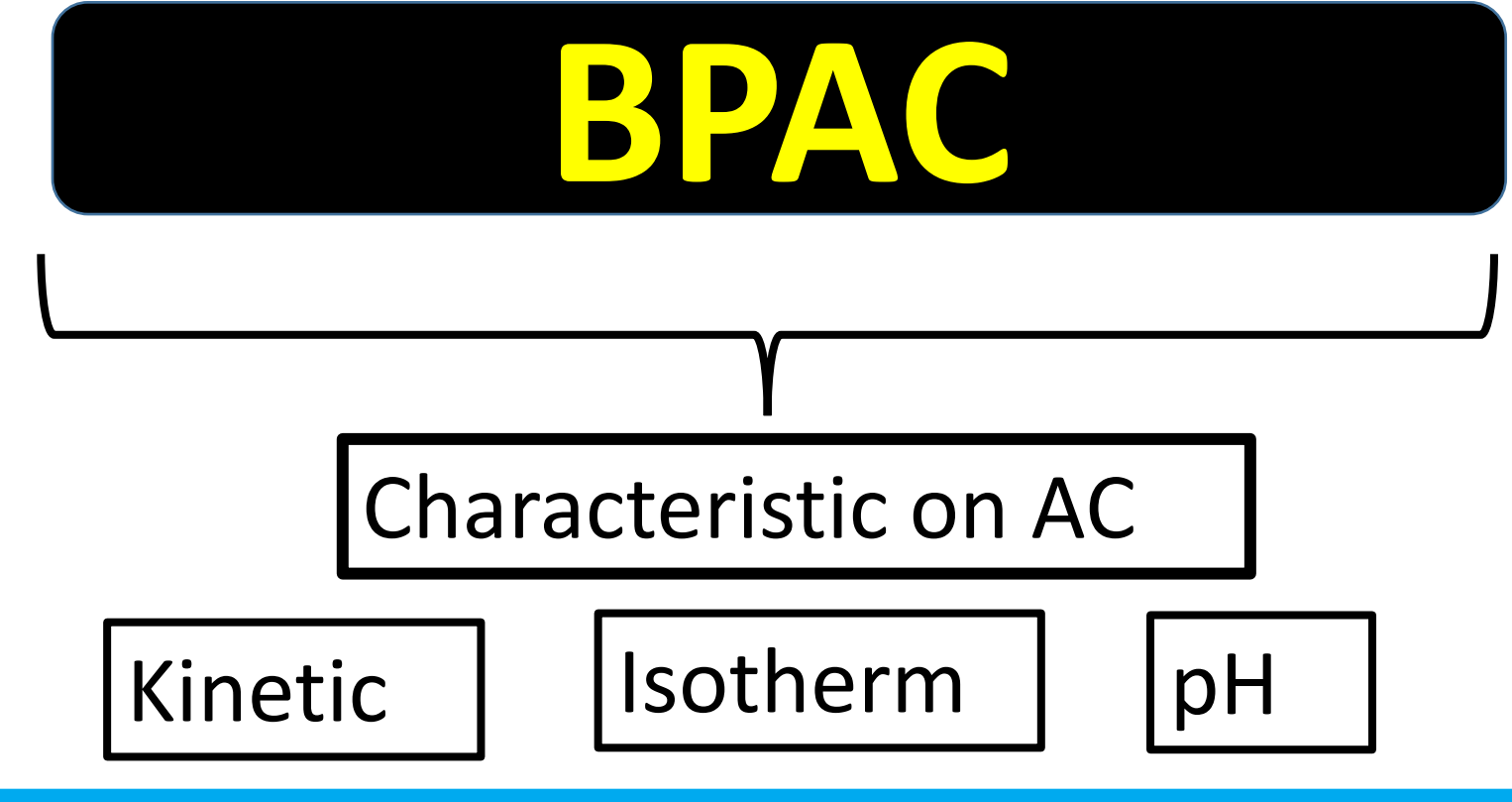
- The presence of persistent micropollutant causes a negative effect on aquatic organisms and human health.
- One of the reasons for their occurrence in environment is partial removal in conventional wastewater treatment plants.



✓ Can AC from banana peel waste (BPAC) replace commercial AC for diclofenac removal?

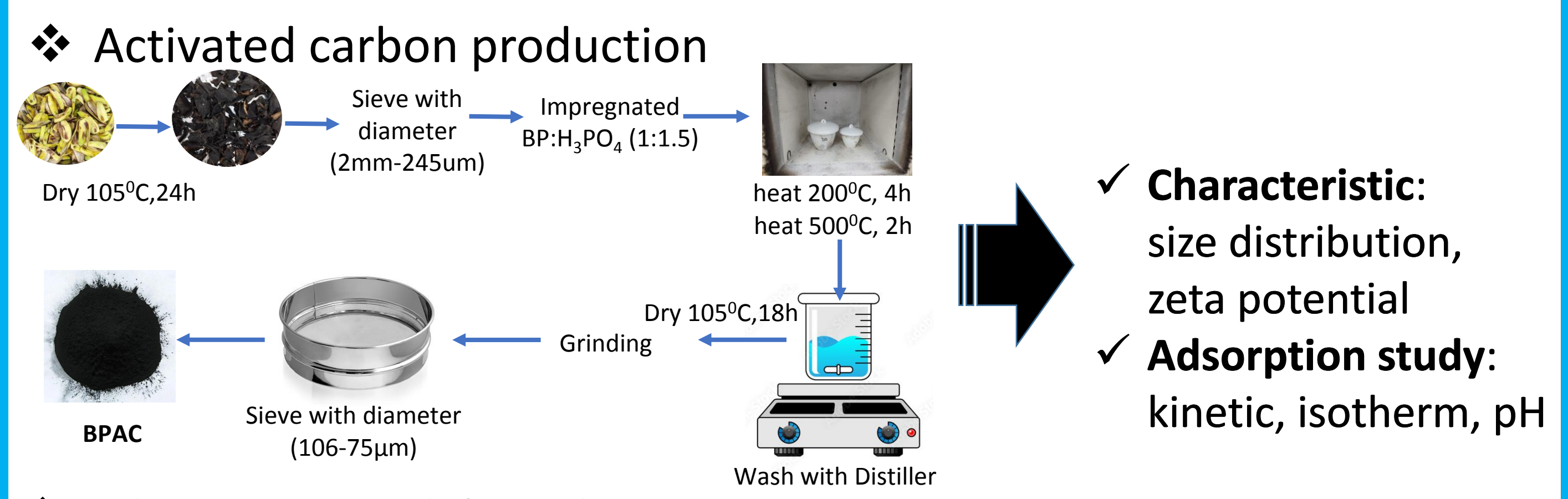
Objective

Understand mechanisms involved in the adsorption of diclofenac by using new biowaste (banana peel)



- Activated carbon (AC) adsorption could improve the removal of micropollutants.

METHODS

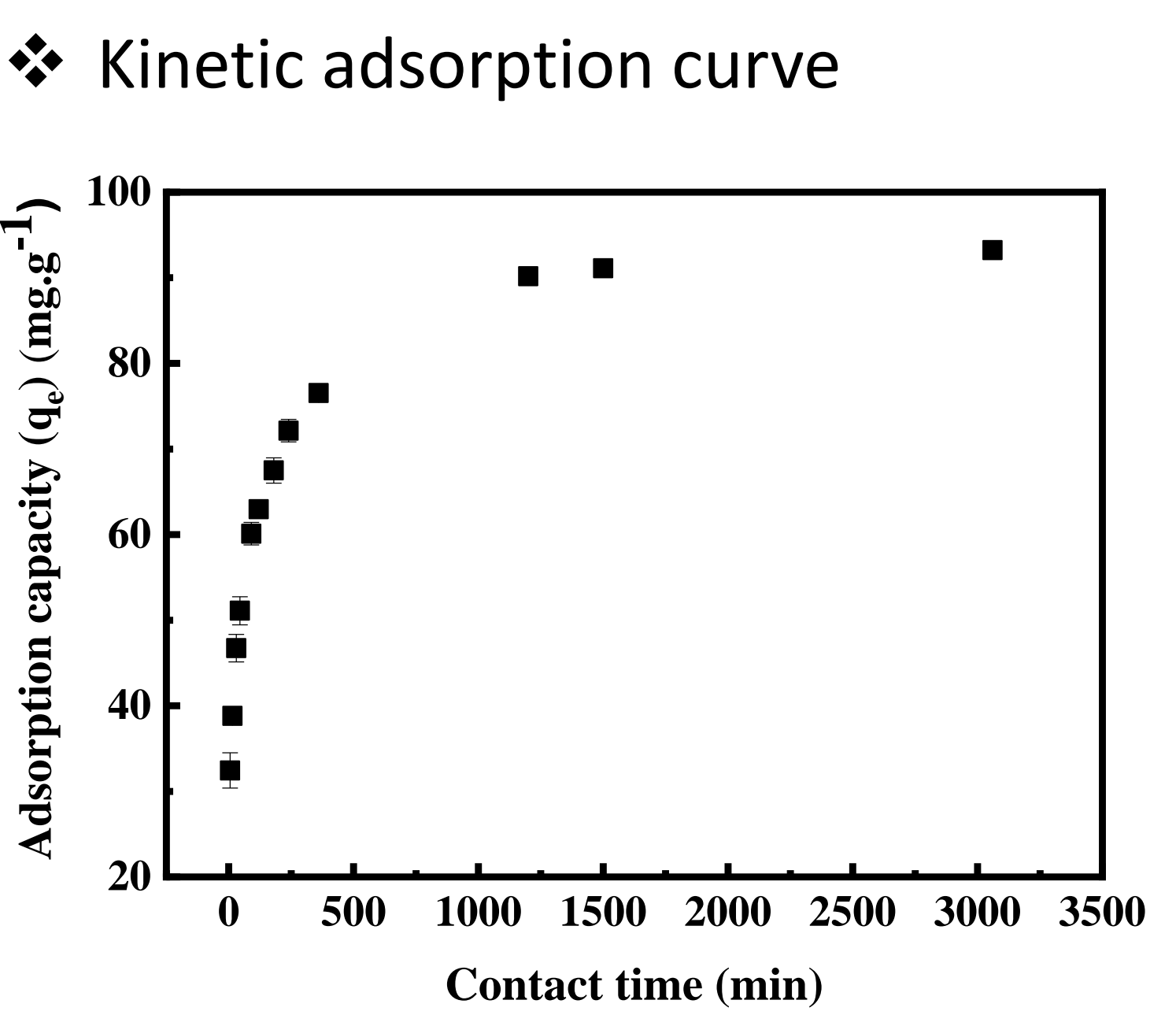


❖ Adsorption model used

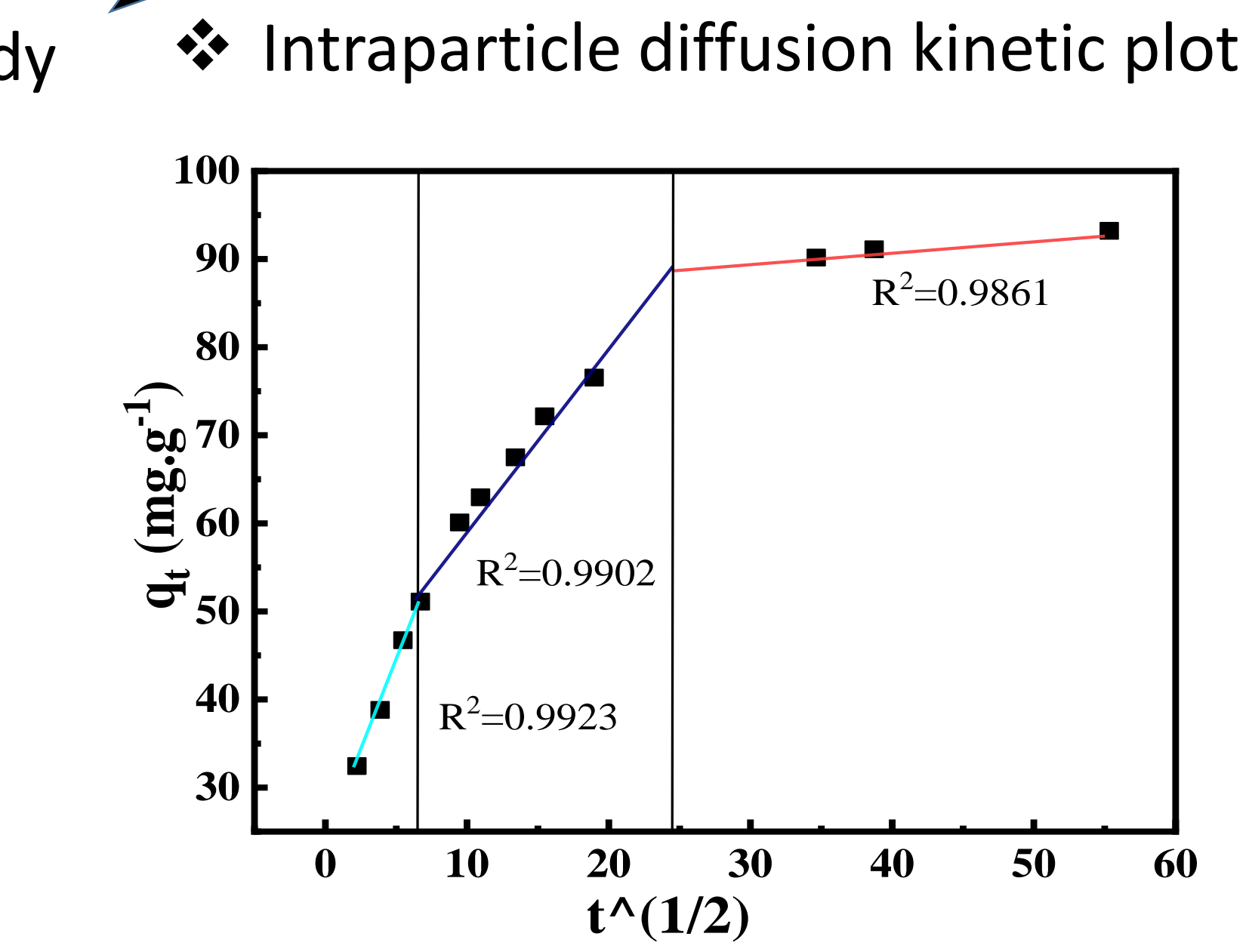
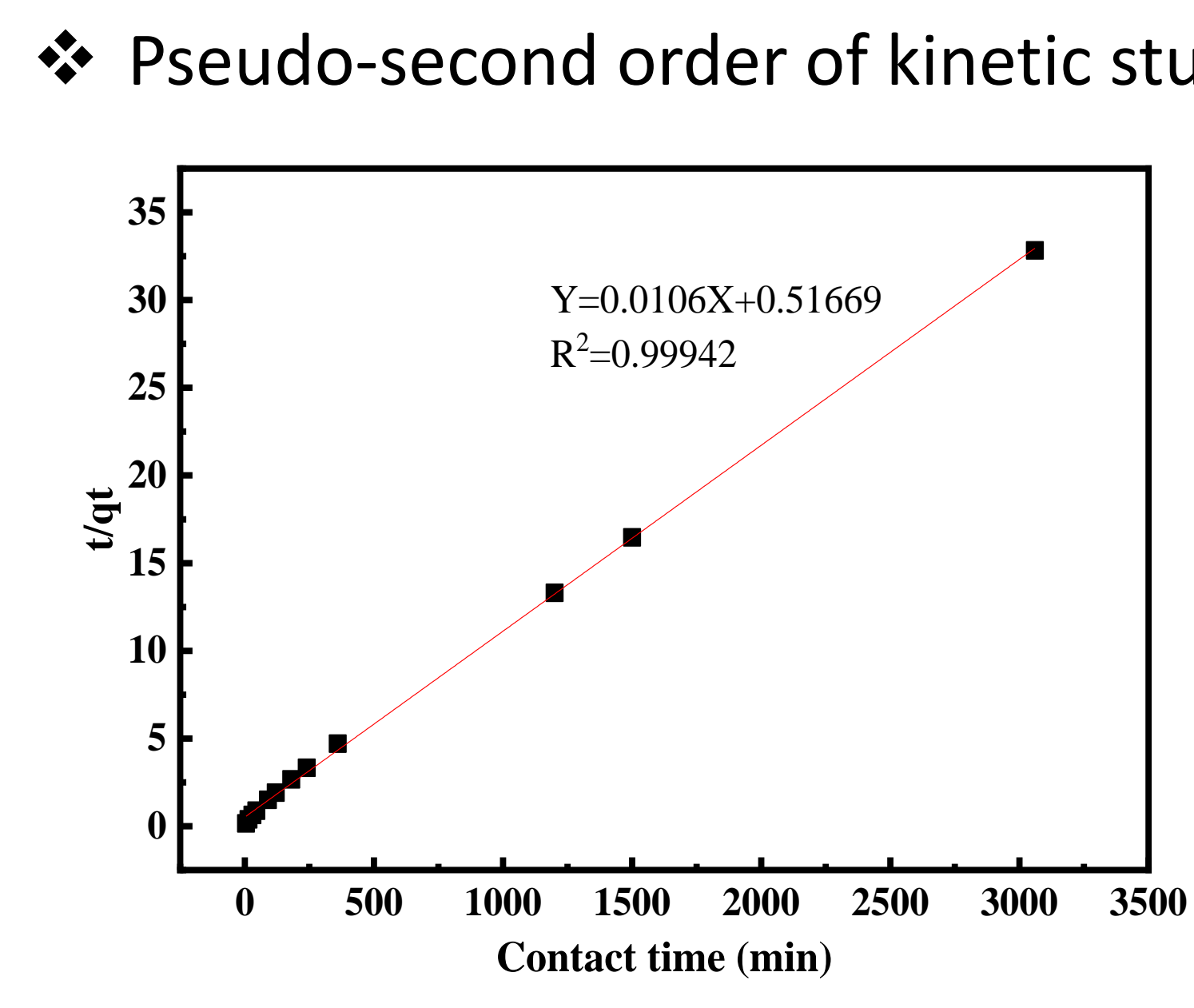
Experiments	Models	Linear form	Phenomena
Kinetic: AC: 0.5g.l ⁻¹ DCF: 100mg.l ⁻¹ Time: 0,5,15min ...until 3060min T:20°C	Pseudo-first order	$\log(q_e - q) = \log q_e - \left(\frac{k_1}{2.303}\right)t$	Physisorption
	Pseudo-second order	$\frac{t}{q} = 1/k_{id} q_e^2 + \left(\frac{1}{q_e}\right)t$	Chemisorption
	Intraparticle diffusion	$q_t = K_{id} t^{1/2} + C$	Mass transfer
Isotherm: AC: 0.2g.l ⁻¹ DCF: 2,4,6,8 and 10mg.l ⁻¹ Time:24h and T:20°C	Langmuir	$\frac{C_e}{Q_e} = \frac{1}{K_f Q_m} + \frac{C_e}{Q_m}$	Monolayer
	Freundlich	$\ln(Q_e) = \frac{1}{n} \ln(C_e) + \ln(K_f)$	Multi layer

RESULTS

Adsorption kinetic



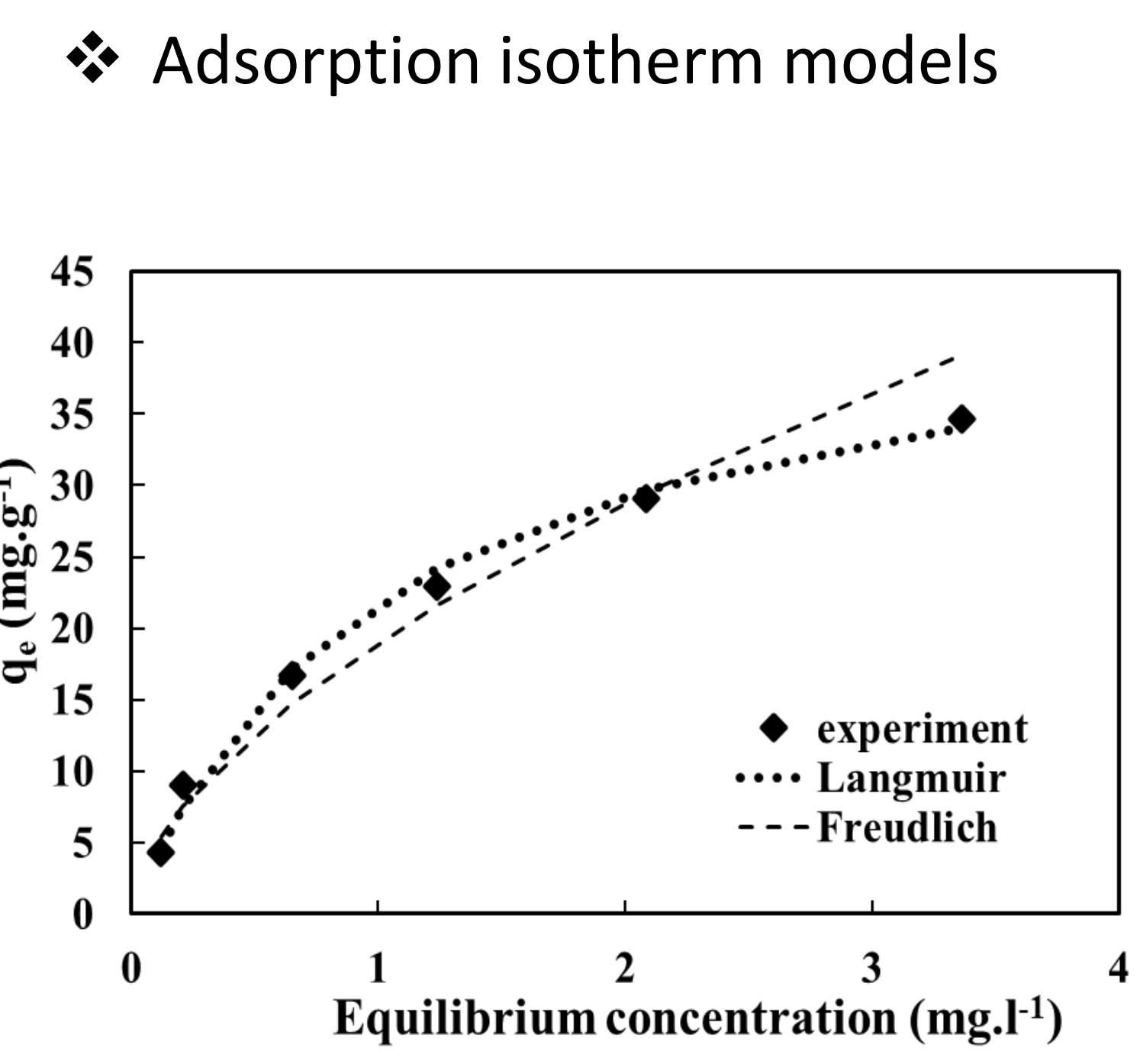
- Speed of adsorption was fast in the early stage 0-90min.
- Experimental result was best fitted with pseudo second order.
- The experimental kinetic data was plotted by using intraparticle diffusion modelling. It might be not rate-limited step in this process.



DISCUSSIONS

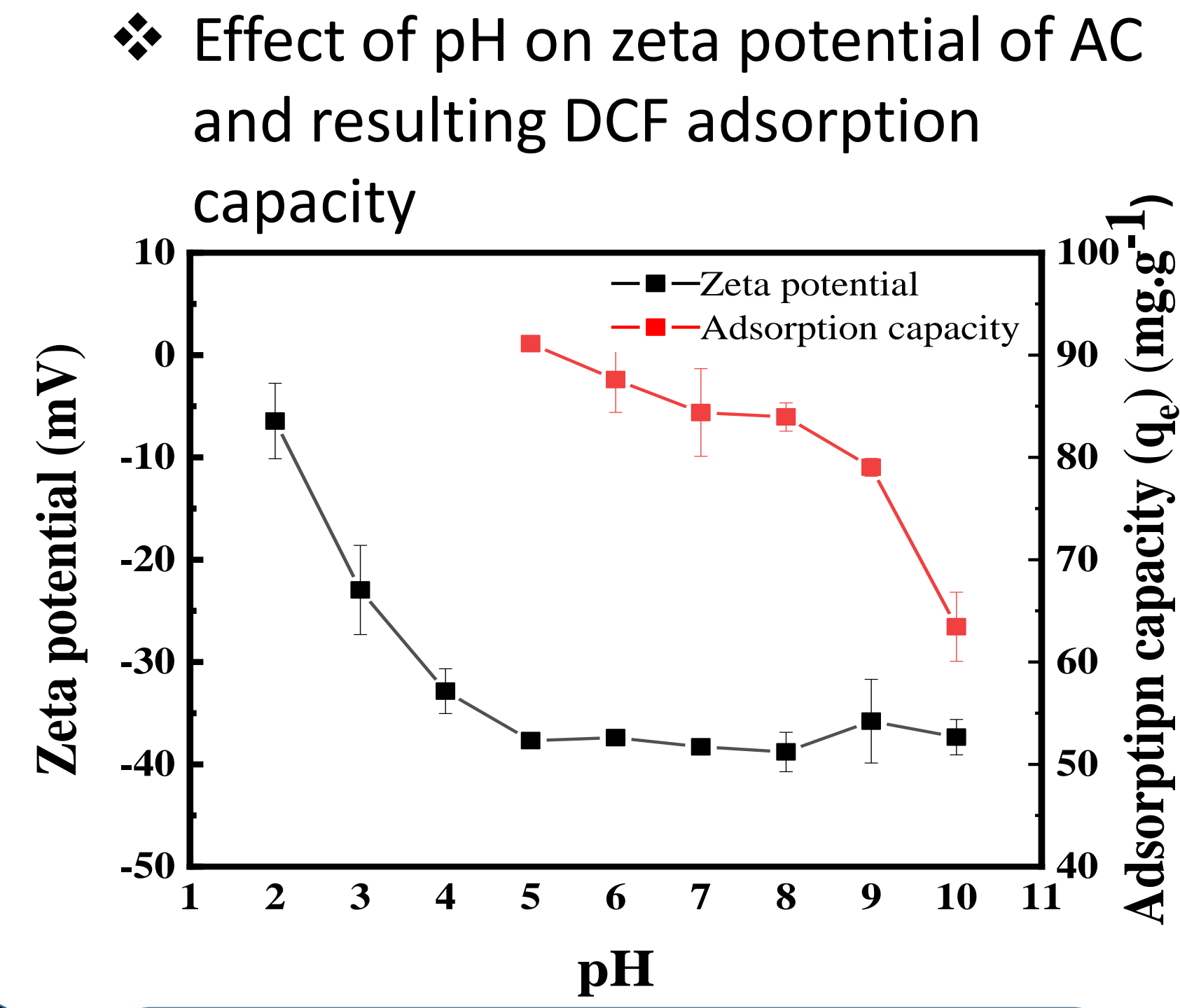
- The maximum adsorption capacity with experimental data was 93mg.g⁻¹.
- Pseudo-second order indicated that the adsorption could be controlled by a chemisorption process that electrons sharing between molecules of DCF and AC's surface group.
- Adsorption process might involve multi-stage adsorption:
 - 1st stage (0-90 minutes) represented the external mass transfer resistance involving the particle's surface.
 - 2nd stage (90-600 min) indicated a more gradual adsorption, characteristic of the adsorbate transport through the adsorbent inner surface.
 - 3rd stage (600-3060 min) represented to the adsorption equilibrium.
- Langmuir model indicated that diclofenac adsorption took place onto a homogenous surface.
- The activated carbon was negatively charged.
- q_e gradually decreased when pH was greater from 6-10 possibly due to an increase number of deprotonated species (-COO and O-) of DCF(Pka=4.15) inducing electrostatic repulsion at high pH between negative charges of DCF and AC.

Isotherm study



❑ Adsorption isotherm result was best fitted with Langmuir.

Effect of adsorption pH



❑ q_e gradually decreased when pH was greater from 6-10.

Comparison with commercial AC

- q_e=195mg.g⁻¹ (commercial activated carbon) > q_e=93mg.g⁻¹ (banana peel).
- The banana peel AC showed comparable adsorption capacities than other alternative adsorbent such as activated carbon tea waste (91.2 mg.g⁻¹), coco shell (63.47 mg.g⁻¹) (Malhotra et al., 2018, Saucier et al., 2015).

REFERENCES

Malhotra et al., 2018 "Tea waste derived activated carbon for the adsorption of sodium diclofenac from wastewater : adsorbent characteristics , adsorption isotherms , kinetics , and thermodynamic" Environmental Science and Pollution Research , 32210-32220.

Saucier et al., 2015 "Microwave-assisted activated carbon from cocoa shell as adsorbent for removal of sodium diclofenac and nimesulide from aqueous effluents" Journal of Hazardous Materials, 289, 18-27.