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Jiawei Ren, Yun Chul Woo, Minwei Yao, Leonard D. Tijning, Ho Kyong Shon. *Enhancement of nanoscale zero-valent iron immobilization onto electrospun polymeric nanofiber mats for groundwater remediation.* Pages 200-208.

A new approach that combines nanoscale zero-valent iron (nZVI) with electrospinning technology has been put forward to avoid nZVI agglomeration and a secondary pollution. In this study, to enhance the immobilization of nZVI particles onto the polyacrylic acid (PAA)/polyvinyl alcohol (PVA) electrospun nanofiber mat, mats (M1, M2 and M3) with different PAA/PVA mass ratios (1:1, 2:1 and 3:1) were tested for the immobilization of nZVI particles and their performance of removing contaminants. The results indicate that M3 immobilized the most nZVI particles (48.4 wt% on the mat, ~2.5 times the figure for previous study) and had the highest removals to methylene blue and Cu(II) ions at 94% and 83.6% respectively, resulting from more free carboxylic groups available on the cross-linked nanofibers as well as a higher porosity into the mat. Therefore, increasing the PAA/PVA ratio is effective to boost the performance of nZVI-PAA/PVA electrospun nanofiber mat, which has a great potential for the application of nZVI-targeted contaminants remediation.

- **Keywords:** nZVI particles, Electrospinning, Polymer nanofibers, Immobilization, —COOH/—OH ratio, Groundwater remediation, Zero-valent iron

Siew Cheng Low, Nicky Eshtiaghi, Li Shu, Rajarathinam Parthasarathy. *Flow patterns in the mixing of sludge simulant with jet recirculation system.* Pages 209-221.

In this study, we examined the efficiency of mixing due to liquid jets in a model anaerobic digester. Xanthan Gum Keltrol T (XGKT) solution which is transparent and has similar rheological characteristics to those of digested sludge was selected as the model liquid. Experiments were carried out using 0.15 and 0.4 wt% XGKT solutions. Four different liquid jet orientations were used in a cylindrical vessel, namely vertical-downward, vertical-upward, tangential 45° upward and tangential 45° downward. A decolourisation method involving an acid–base reaction was used for flow visualisation. A fluorescent dye was used as the tracer to observe the mixing patterns in the vessel.

Video images of flow visualisation experiments were analysed to investigate the changes in the volume of well-mixed regions as a function of mixing time. The results from flow visualization were compared with those from both computational flow dynamics (CFD) simulations and electrical resistance tomography (ERT). Results showed that well mixed region volume decreases with increasing liquid apparent viscosity. Complete mixing was achieved in 0.15 wt% XGKT solution, which has rheology similar to that of digested sludge with 2.3% solids, with all four different jet arrangements. For 0.4 wt% XGKT solution, which has rheology similar to that of digested sludge with 5% solids, mixing efficiency with jet arrangement changes in the following order: upward > 45° upward > 45° downward > downward jet arrangement. The results suggested that we can use transparent materials to study rheological behaviours of sludge and visualize the dynamics of mixing. Results from both ERT and CFD agreed well with those from flow visualization experiments.

- **Keywords:** Flow visualization, Jet recirculation, Hydraulic mixing, ERT, Anaerobic digesters, CFD modeling, Sludge simulant, Inactive volume

Sultan K. Alharbi, Jinguo Kang, Long D. Nghiem, Jason P. van de Merwe, ... William E. Price. *Photolysis and UV/H₂O₂ of diclofenac, sulfamethoxazole, carbamazepine, and trimethoprim: Identification of their major degradation products by ESI-LC-MS and assessment of the toxicity of reaction mixtures. Pages 222-234.*

The photolysis of diclofenac (DCF), sulfamethoxazole (SMX), carbamazepine (CBZ), and trimethoprim (TMP) was investigated using a low-pressure (LP) mercury ultraviolet (UV) lamp (254 nm) and a combination of UV with hydrogen peroxide (H₂O₂). For each experiment, 5 mg/L of each pharmaceutical was prepared in pure water and individually degraded by either UV alone or UV/H₂O₂. DCF and SMX were highly susceptible to UV treatment and completely degraded to below their LC-MS detection limit (1 µg/L) after only 8 min of UV irradiation. TMP and CBZ were more resistant to UV treatment, with only 58.2 and 25.2% degradation (after 1 h UV exposure). The combination of H₂O₂ addition (up to 0.2 g/L) with UV significantly improved the removal rate of TMP and CBZ up to 91.2 and 99.7% of the initial concentration, respectively. A number of novel transformation compounds were identified as UV or UV/H₂O₂ degradation products using LC-MS. The range and amount of these transformation compounds strongly depended on the applied treatment conditions. The toxicity of each pharmaceutical solution before and after treatment was also evaluated and all parent compounds were non-toxic at the tested concentration (i.e. 5 mg/L). DCF, in particular, but also CBZ and SMX, showed an increase in solution toxicity after treatment with UV only, indicating the presence of photolytic degradation products that are more toxic than the parent compounds. Treatment with UV/H₂O₂ reduced the toxicity of all solutions to below the detection limit of the assay.

- **Keywords:** UV photolysis, UV/H₂O₂, Advanced oxidation proces, Degradation product identification, BLT-Screen, Wastewater treatment

Jih-Hsing Chang, Chin-Pao Huang, Shu-Fen Cheng, Shan-Yi Shen. *Transport characteristics and removal efficiency of copper ions in the electro dialysis process under electroconvection operation. Pages 235-242.*

Three distinct operational conditions, namely, ohmic, limiting current, and electroconvection region, respectively, can be created by applying different electric fields during ED operations. The fundamental of cation transport under ohmic and limiting current is well understood, however, the mechanism on cation transport under electroconvection is unclear. In order to clarify the feasibility of operating ED under

electroconvection for the treatment of industrial wastewater (copper ion as the target pollutant), the methods of current–voltage profiling (C–V curve) and electrochemical impedance spectroscopy (EIS) were used to study the transport characteristics of Cu^{2+} through a cationic exchange membrane (CEM). The relevant operational parameters obtained above under electroconvection conditions were applied to a continuous ED system as to investigate the removal efficiency of Cu^{2+} -containing wastewater.

Results indicated that ED system operated under electroconvection conditions was able to achieve high Cu^{2+} removal efficiency (around 74% in 4-min treatment) at high electricity efficiency as the theoretical calculation (based on Cu^{2+} transport number close to 1.0). The pH of copper wastewater in the ED system decreased slightly from 4.7 to 4.0 under electroconvection operation. The interface at the membrane–water was perturbed by the electroconvection operation, which facilitated ions transport across the membrane. An equivalent circuit composed of the R_s , C_m and R_m (parallel circuit representing the CEM), and constant phase element described well the Cu^{2+} transport behavior in the membrane–solution system according to the p value is greater than 1.0.

- **Keywords:** Copper wastewater, Electrodialysis, Electroconvection, Electrochemical impedance spectroscopy, Transport number

Cheng-Di Dong, Chiu-Wen Chen, Chih-Ming Kao, Chang-Mao Hung. *Synthesis, characterization, and application of CuO-modified TiO₂ electrode exemplified for ammonia electro-oxidation. Pages 243-253.*

In this study, a copper nanoparticle-modified titanium dioxide (CuO-TiO_2) catalyst was synthesized using the coprecipitation method with $\text{Cu}(\text{NO}_3)_2$ as the active component for the electrochemical oxidation (ECO) of ammonia (NH_3). The voltammetric behavior and characterization of the electrocatalyst, including oxidation behavior, were investigated using linear sweep voltammetry (LSV), polarization, and chronoamperometric measurements, combined with SEM, FTIR, XRD, EEFM and XPS. SEM and XRD spectroscopy revealed that CuO particles were highly dispersed on the anatase phase of the TiO_2 -supported surface. The XPS and FTIR analysis indicated that CuO was firmly deposited through the linkage of Cu-O-Ti bonding to the TiO_2 base and the sample exhibiting the stretching vibration mode associated with the Cu-O bonds of the CuO nanoparticle. Results of EEFM analysis indicate that significant excitation/emission plots located at 218/280 nm is associated with the CuO nanoparticle. The LSV oxidation ability could explain the catalytic activities of the CuO-TiO_2 electrocatalysts, and NH_3 oxidation peak current on the CuO-TiO_2 electrocatalyst increased as scan rates increased, indicating that the adsorption-controlled process occurred at the electrocatalyst.

- **Keywords:** CuO-TiO_2 electrocatalyst, Electro-oxidation, EEFM, Linear sweep voltammetry (LSV), NH_3

Qiang Kong, Xiao He, Li Shu, Ming-sheng Miao. *Ofloxacin adsorption by activated carbon derived from luffa sponge: Kinetic, isotherm, and thermodynamic analyses. Pages 254-264.*

Ofloxacin (OFL) removal from aqueous solution by carbon activated made from luffa sponge was studied. Scanning electron microscopy showed that the activated carbon (AC) surface was rough. The AC surface area was $834.008 \text{ m}^2/\text{g}$ and the average pore diameter was 5.35 nm. AC adsorbed 96% of OFL at a concentration of 30 mg/L, and the maximum amount of OFL adsorbed was about 132 mg/g. The AC adsorption kinetic data fitted a pseudo-second-order model ($R^2 = 0.9997$) well, indicating chemisorption control. The experimental data at 308 K best fitted the Freundlich isotherm equation ($R^2 = 0.9912$), indicating multilayer adsorption. A thermodynamic simulation showed that adsorption was spontaneous and exothermic. The optimal conditions for OFL adsorption were pH 6, initial OFL concentration 30 mg/L, temperature 293 K, and AC dosage

0.5 g/L. Fourier-transform infrared spectroscopy showed that phosphorus-containing functional groups, and C=O, C—O—C, and C=C bonds were present on the AC surface.

- **Keywords:** Luffa sponge, Activated carbon, Ofloxacin, Adsorption, Kinetics, Isotherm

G. Kastl, I. Fisher, A. Sathasivan. *Scan of water treatment processes to achieve desirable chlorine stability in water supply systems. Pages 265-273.*

Removal of natural organic matter (NOM) is increasingly important in production and distribution of drinking water complying with health and aesthetic guidelines. The impact of treatment is often investigated using the resulting dissolved organic carbon (DOC) concentration and trihalomethane formation potential. Water treatment processes of ferric and alum coagulation with and without pre-oxidation by ozone and permanganate were scanned for their ability to treat synthetic raw water from peat extract. To compare the efficiency of the treatment methods the dissolved organic carbon (DOC) concentration and chlorine decay and trihalomethane (THM) formation tests — the important parameters needed in practice were used. A high level of DOC removal (>80%) was achieved with all the treatments. A significant difference was observed in chlorine decay rates and THM production. Pre-oxidation with 2 mg/L of O₃ and coagulation with 45 mg/L of ferric sulphate produced the most chlorine stable water followed by water treated with 80 mg/L of ferric sulphate. Chlorine decay test was found to be a more sensitive indicator of a successful treatment than DOC. The optimisation of the ozone dose is likely to identify the best water quality and chemical cost combination which is not likely achievable by the coagulation alone.

- **Keywords:** NOM removal, DOC removal, Coagulation, Chlorine decay model, THMs formation, Pre-ozonation

Li-jun Luo, Junhong Li, Jianhui Dai, Lihong Xia, ... Min Yang. *Bisphenol A removal on TiO₂-MoS₂-reduced graphene oxide composite by adsorption and photocatalysis. Pages 274-279.*

Bisphenol A (BPA) is a well-known, representative endocrine disruptor chemical, which can cause adverse effects on human health and environment. In this work, we prepared TiO₂-MoS₂-reduced graphene oxide (denoted as TiO₂-MoS₂-RGO) ternary hybrid photocatalyst to remove it by adsorption and photocatalysis. The prepared photocatalyst were characterized by transmission electron microscopy (TEM), X-ray diffraction (XRD). The mass ratio of MoS₂ in the composite was optimized. The results indicated that the anatase TiO₂ and MoS₂ were anchored on the reduced graphene oxide, and the optimum mass ratio of MoS₂ in TiO₂-MoS₂-reduced graphene oxide was 1.0% (denoted as TiO₂-1MoS₂-RGO). Under the same photocatalytic degradation condition, BPA adsorption removal ratios over TiO₂, P25, TiO₂-1MoS₂, TiO₂-RGO and TiO₂-1MoS₂-RGO were 0.75%, 0.79%, 2.30%, 24.00% and 22.10%, photocatalytic degradation removal ratios were 17.20%, 19.90%, 27.33%, 26.30% and 40.30% and the total removal ratios were 17.95%, 21.69%, 29.66%, 50.30% and 62.40%, respectively. The results indicated that TiO₂-1MoS₂-RGO exhibited highest adsorption and photocatalytic degradation activity among them and the introduction of MoS₂ in the TiO₂-RGO can reduce the electron-hole pair combination and enhance photocatalytic activity of TiO₂ for BPA greatly.

- **Keywords:** Photocatalysis, TiO₂, Graphene, MoS₂, Heterojunction, BPA

Helena Khatoon, Noorazilah Haris, Sanjoy Banerjee, Norazira Abdu Rahman, ... Azizah Endut. *Effects of different salinities on the growth*

and proximate composition of *Dunaliella* sp. isolated from South China Sea at different growth phases. Pages 280-287.

Environmental factors, growth phase and microalgal strain have been reported to influence the chemical composition of microalgae. Salinity is one of the important culture conditions that can influence growth and proximate composition of microalgae. *Dunaliella* sp. is a commercial microalgae species that has been widely used in various sectors due to its biochemical composition. It is also well known to tolerate a wide range of salinity. In the present study, effect of different salinities (10, 30 and 50 ppt) on the growth and proximate composition of *Dunaliella* sp. at different growth phases were evaluated. Results showed that growth of *Dunaliella* sp. was significantly higher ($p < 0.05$) and faster at 10 ppt compared to 30 and 50 ppt. Protein, lipid and carbohydrate content were also higher at 10 ppt. Significantly higher ($p < 0.05$) protein content was observed in stationary phase (10 ppt). In addition, carbohydrate content was also significantly higher ($p < 0.05$) in stationary phase for 10 ppt. However, higher lipid content was recorded in exponential phase (10 ppt) compared to other phases and salinities. The findings of this study can be manipulated for high biomass production of *Dunaliella* sp. for commercial use.

- **Keywords:** Salinity, Growth, Proximate composition, *Dunaliella* sp.

S.H. Hamdan, W.W.F. Chong, J.-H. Ng, C.T. Chong, S. Rajoo. A study of the tribological impact of biodiesel dilution on engine lubricant properties. Pages 288-297.

The switch from petro-diesel fuel to biodiesel blends for Compression Ignition engines have raised tribological performance concerns among major automobile manufacturers. Biodiesel dilution on engine lubricants could have adverse long-term effects on the engine efficiency, which will reduce the fuel economy, thus, leading to higher greenhouse gas emissions. Therefore, this study investigates the tribological impact of palm methyl ester (PME) diluted in SAE5W40 and SAE10W40 engine lubricants along different lubrication regimes under engine cold start condition. Through lubrication Stribeck curve analysis conducted using a pin-on-disc tribometer, coefficient of friction (CoF) for both engine lubricants showed parabolic maximum behaviour with increasing PME dilution. The CoF reduction beyond these peak values is attributed to the improved friction modifier effect from the now-dominant PME but with reduced load carrying capacity. An effective lubricant should possess both reasonable friction modifier effect and highest load carrying capacity in mitigating boundary friction. Hence, through the study, it could be deduced that the acceptable PME dilution threshold level for SAE5W40 is up to 17.5-vol%, while for SAE10W40 is between 28.0-vol% and 34.5-vol%. PME dilution levels beyond these thresholds could easily cause lubrication film rupture under high load, high shear rate conditions during application along the mixed to boundary lubrication regimes, inducing material wear.

- **Keywords:** Biodiesel dilution, Tribometer, Lubrication Stribeck curve, Friction, Engine lubricant, Palm Methyl Ester

Chin Boon Ong, Abdul Wahab Mohammad, Law Yong Ng, Ebrahim Mahmoudi, ... Nur Hanis Hayati Hairom. Solar photocatalytic and surface enhancement of ZnO/rGO nanocomposite: Degradation of perfluorooctanoic acid and dye. Pages 298-307.

In this work, ZnO/rGO nanocomposites (NCs) were synthesized through a low temperature sol-gel method. Zinc oxide decorated on graphene sheets could provide surface enhancement and hinder the rapid recombination rate of electron hole pairs that occur during a photocatalysis process. It has been observed that the loading of ZnO

decorated on graphene sheets is important in controlling the morphologies and surface enhancement of ZnO/rGO NCs. Field Emission Scanning Electron Microscope (FESEM) micrographs reveal that spherical shape and hexagonal-based nanopyramid of ZnO can be formed at low and high loading of ZnO, respectively. NCs showed excellent performance for degradation of perfluorooctanoic acid (PFOA) and methyl orange in aqueous solution under solar irradiation. Herein, mechanisms for the formation of different shapes of ZnO nanostructures decorated on graphene and their enhancement towards surface and photoactivity were discussed in details.

- **Keywords:** Photocatalytic, ZnO/rGO, Nanocomposites, Perfluorooctanoic acid, Methyl orange, Solar photocatalysis

Mei-Wen Shih, Ching-Ju Monica Chin, Yi-Ling Yu. *The role of oxygen-containing groups on the adsorption of bisphenol-A on multi-walled carbon nanotube modified by HNO₃ and KOH.* Pages 308-314.

The adsorption of bisphenol-A (BPA) on multi-walled carbon nanotubes (MWCNTs) was investigated in this study. To distinguish the influences of surface area and oxygen-containing functional groups, the as-purchased MWCNTs (A-MWCNTs) were treated by HNO₃ (N-MWCNTs) and KOH (K-MWCNTs). The adsorption capacity of N-MWCNTs was less than that of A-MWCNTs at neutral pH due to the steric obstruction resulted from the oxygen-containing functional groups on the N-MWCNTs. The adsorption capacities of BPA on all three types of MWCNTs decreased when the pH values increase to 10 or 11, at which the electrostatic repulsions between the dissociated surface groups and BPA arose. Also, it was found that although the N-MWCNTs and the K-MWCNTs had about the same amount of the oxygen-containing surface groups, their ratios of the adsorption amount at solution pH 11 to that at pH 5 (q_{11}/q_5) were different. This indicated that not only the amount but also the types of the oxygen-containing groups would affect the interaction between aromatic compounds and MWCNTs. The dissociation of —OH groups and water-clustering would have more significant hindering effects than the carboxylic groups for the adsorption of BPA by MWCNTs at high pH.

- **Keywords:** Adsorption, Carbon nanotubes, π - π interaction, Water clustering, Endocrine disruptor, Nanomaterial

Nor Afzanizam Samiran, Jo-Han Ng, Mohammad Nazri Mohd Jaafar, Agustin Valera-Medina, Cheng Tung Chong. *Swirl stability and emission characteristics of CO-enriched syngas/air flame in a premixed swirl burner.* Pages 315-326.

There is significant variation in the composition of synthesis gas derived from biomass, coal or waste. The inconsistency of syngas constituents poses challenges and requires thorough characterisation prior to use as alternative fuel in practical combustion system. The present study investigates the combustion and emission characteristics of CO-enriched syngases by using an atmospheric premixed swirl flame burner. High (CO/H₂ = 3) and moderate (CO/H₂ = 1.2) CO-enriched syngases were fully premixed with air and diluents of CH₄ and CO₂ prior to ignition at the burner outlet. Direct flame imaging shows that moderate CO-enriched syngas produces less luminous flames than high CO-rich syngas, signifying less tendency to form soot. Moderate CO-rich syngases show more compact flames with higher intensity owing to higher H₂ contents. The blowout test shows that higher CO content syngases result in lean blowout at higher equivalence ratios, posing stability issues. High fractions of unreactive CO₂ and reactive CH₄ in syngases result in higher lean blowout limit. Emissions wise, high CO-rich syngases show evidently less NO_x emissions as compared to baseline pure CO flames at increasing equivalence ratios. Moderate CO-rich flame exhibits higher NO_x level than high CO-rich at $\phi < 0.8$. However, at fuel-stoichiometric and fuel-rich regions they display

similar levels of NO_x. Higher fraction of CO₂ dilution results in reduction of NO_x emissions, with pronounced impact on fuel-rich cases. There was minimal effect on CO emissions with increased dilution of CO₂.

- **Keywords:** CO-rich, Syngas, Lean blowout limit, Stability, Emissions, Premixed flame

Mi-Jin Jeon, Yong-Woo Jeon. *Characteristic evaluation of activated carbon applied to a pilot-scale VSA system to control VOCs. Pages 327-334.*

This work investigates the characteristics of activated carbon sampled after repeated adsorption/desorption cycles to indirectly evaluate the performance of a 30 m³/min pilot-scale VSA system installed in a paint factory. The onsite pilot VSA system was operated continuously for 20 adsorption/desorption cycles during a 40 day period. Samples of commercial activated carbon (raw) and regenerated activated carbon after 10 cycles and 20 cycles (10A, 10B, 20A, 20B) were prepared. The changes in physical properties were analyzed based on N₂ adsorption-desorption. Changes in the adsorption capacity were measured using a toluene adsorption test and DTG analysis. Depending on the VSA cycle increase, minimal physical changes in the activated carbon were observed, except for a decrease in the BET surface area. As a result of the toluene adsorption test, at 20 cycles at least 85% of the performance of activated carbon was maintained. However, as the VSA cycles were increased from 10 cycles to 20 cycles, the toluene adsorption capacity was found to be slightly reduced or maintained. Based on the DTG analysis, the cause of the performance degradation seems to be the formation of a heel, which is the non-desorbed physisorption observed for regenerated activated carbon.

- **Keywords:** Volatile organic compounds, Activated carbon, Vacuum swing adsorption, Low-temperature desorption, Regeneration, Pilot study, Paint factory

Yongze Liu, Haowan Sun, Liqiu Zhang, Li Feng. *Photodegradation behaviors of 17β-estradiol in different water matrixes. Pages 335-341.*

17β-Estradiol (E2), a typical endocrine disrupting compound, is frequently detected in aquatic environments, and this has caused serious concerns about its potential risks. In this study, the photodegradation behaviors of E2 in ultrapure water and different water matrixes such as those containing HCO₃⁻, NO₃⁻, NO₂⁻, and humic acid (HA) were investigated under simulated irradiation using a 300-W xenon lamp. The results showed that E2 photodegradation in all cases followed pseudo-first-order kinetics. In ultrapure water, the photodegradation rate constant and half-life of E2 were 0.1304 h⁻¹ and 5.32 h, respectively. The contributions of direct photolysis, hydroxyl radicals (.OH), and singlet oxygen free radicals (¹O₂) to E2 removal were 72%, 21.2%, and 6.8%, respectively. The effects of different concentrations of HCO₃⁻, NO₃⁻, NO₂⁻, and HA on the photodegradation behavior of E2 were clearly different. In the presence of HCO₃⁻ (0.16–2.46 mM), the E2 removal rate decreased from 0.1236 to 0.1144 h⁻¹ as the HCO₃⁻ concentration increased. Quenching experiments revealed that the contribution of .OH decreased gradually from 21.2% to 10.9% in the presence of HCO₃⁻. In contrast, in the presence of NO₃⁻ (0–1.29 mM), NO₂⁻ (0–1.29 mM), and HA (0–24 mg/L), the E2 removal rates increased significantly as their concentrations increased, and quenching experiments revealed that the contribution of .OH increased to 24.8%, 29.1%, and 62.4%, respectively. It can be concluded that hydroxyl radicals were predominantly responsible for the indirect photodegradation of E2.

- **Keywords:** Photodegradation, Kinetics, 17β-estradiol, Water matrixes, Hydroxyl radicals, Singlet oxygen

Takaaki Wajima. A new carbonaceous adsorbent for heavy metal removal from aqueous solution prepared from paper sludge by sulfur-impregnation and pyrolysis. Pages 342-352.

A new carbonaceous adsorbent for heavy metals removal was prepared from paper sludge using sulfur impregnation. The sulfur-impregnated carbonaceous adsorbent with heavy metals removal ability can be obtained from sulfur-immersed sludge by pyrolysis. The product pyrolyzed at 400 °C has a maximum removal ability for nickel and lead ions, which has high specific surface area with sulfur-based functional to remove heavy metal ions. The product obtained at 400 °C indicates more effective removal for heavy metals ion than commercial charcoal, especially Ni²⁺ (66.7%) and Pb²⁺ (71.7%). With increasing pH of the solution, the adsorptions of Ni²⁺ and Pb²⁺ were increased and maximum removals of Ni²⁺ and Pb²⁺ were 99.6% above pH 7 and 100% above pH 6, respectively. The equilibrium data for nickel ion was found to fit the Langmuir isotherm better than Freundlich isotherm, with the calculated maximum adsorption capacity of 0.63 mmol/g, whereas the adsorption kinetics followed the pseudo-second-order kinetic model. The thermodynamic values, ΔG^0 , ΔH^0 and ΔS^0 , indicated that adsorption was an endothermic and spontaneous process. The adsorbent can remove nickel ion from high saline water selectively. The desorption of nickel using H₂SO₄ solution is the most effective, but the cycle stability of the adsorbent is low.

- **Keywords:** Paper sludge, Sulfur-impregnation, Heavy metals removal, Pyrolysis, Carbonaceous adsorbent, Recycling

Zhenjuan Duan, Guizhen Li, Libo Zhou, Hua Gui, ... Min Yang. Preparation of zeolite-based zirconium functional materials (Ze-Zr) with the aid of response surface methodology. Pages 353-361.

Zeolite-based zirconium functional materials (Ze-Zr) were obtained by the response surface methodology (RSM). The experimental conditions such as zeolite particle size, the concentration of zirconium oxychloride, mass ratio of zeolite and zirconium, processing time and temperature and assimilation temperature were optimized. The central Box-Behnken design (BBD) and mathematical modelling were adopted for optimizing experimental parameters. FT-IR, XRD and SEM were used to analyze the structure and morphology of the obtained Ze-Zr materials. The Ze-Zr materials with highest phosphorus removal rate of 97.08% were prepared under the following conditions: 0.15–0.20 mm of zeolite, 0.04 M zirconium, mass ratio of 0.09 of zeolite and zirconium, processing for 4 h and 100 °C as drying temperature.

- **Keywords:** Zeolite-based zirconium, Functional materials, Response surface methodology, Phosphorus removal, Adsorption

Chidambaram Kulandaisamy Venil, Ali Reza Khasim, Clairra Arul Aruldass, Wan Azlina Ahmad. Safety evaluation of flexirubin from *Chryseobacterium artocarp* CECT 8497: Acute, sub-acute toxicity and mutagenicity studies. Pages 362-370.

Flexirubin has a broad range of pharmacological effects such as antimicrobial and anticancer activities. The aim of this study was to investigate the adverse effect of flexirubin (*Chryseobacterium artocarp* CECT 8497) by acute, sub-acute (28 days repeated dose) oral toxicity and mutagenicity studies. The acute and sub-acute oral toxicity studies were performed in Sprague-Dawley rats (n – 12; male – 6; female – 6/group) as per OECD 425 (up and down procedure) and OECD 407 guidelines respectively. There was no mortality and signs of toxicity in acute and sub-acute toxicity studies. No test substance related differences were observed in body weight, food consumption, clinical signs, organ weight, haematology and serum biochemical

parameters in treated groups of flexirubin at a target concentration of 1250, 2500 and 5000 mg/kg body weight per day for 28 days. The no-observed-adverse-effect level (NOAEL) of flexirubin was 5000 mg/kg body weight/day, the highest dose investigated. No evidence of mutagenicity was found, either *in vitro* (bacterial reverse mutation assay) or *in vivo* in mice (bone marrow micronucleus assay and sperm shape abnormality assay). The findings of this acute, sub-acute toxicity and mutagenicity studies support the safety of flexirubin extract.

- **Keywords:** Flexirubin, Toxicity, Mutagenicity, Low toxic substance, NOAEL, *C. artocarp*