



# Journal of Applicable Chemistry

2017, 6 (6): 1248-1259

(International Peer Reviewed Journal)



Research Tutorials in Chemistry (RTC)

## Chemical Aims Today (Cat)

### One. (Statistical Evolving) Experimental design (Seed) in Omni\_metrics (O!M)

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In chemistry, the application disciplines, instrumental sensors in operation and thought experimental/computational/ experimental methods in vogue span a wide spectrum with high fidelity in scope and precision. Chemical aims today (Cat, Chart 1) are after hundreds of years of evolution and further evolve to adapt to the challenges of twenty second century.

During twentieth century, the designing of experiment, varying magnitudes of relevant chemical/physico-chemical factors/catalysts etc. was believed to be in the minds/ genes of trained chemists. Statistical experimental design (ED) developed in first half of last century was used in agricultural trials for maximum yield of rice and other cereals. In 1970s, design of experiments using factorial/central composite entered into quantitative and kinetic methods of chemical analysis. With evolutionary changes of Chemometrics, ED has become an integral part chemical activity. The breadthwise application endorsed the positive benefits compared to equal/unequal interval trials and set the flag for its indispensability in critical tasks. Now, Omnimetrics dealing with diverse disciplines with chemical component in the interdisciplinary task from high end contributions employ most of state- of-knowledge tools to ensure not only value-added-end-

#### Chart 1: Cat in nature

Cat belongs to felidae family and species range from domestic cat to wild leopard/lion. The magnificent integrity/diversity is along nature's evolution.



#### CAT (computerized axial tomography) in Medical diagnosis:

is a state-of-knowledge instrument in medical



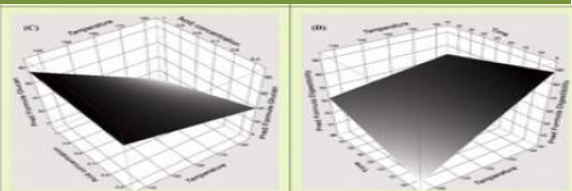
Diagnosis, an outcome of decades' experts' effort; it sees soft-tissues, which are not perceived by X-rays except mapping bones.

### Applications-Instruments-Methods

products but also high quality with desired range of characteristics for foolproof functional utility. Chemical aims today (Cat) with chemical aims in the past (Cap) shall adapt to chemical aims of future evolution (Café).

Statistical *experimental evolving* design (Seed: Statistical *evolving experimental* design) occupies a niche and a high contributing tool in synthesis, manufacturing, quantitative analysis, computations and free parameter setting in instruments. The increasing number of published papers in high impact journals year by year endorses still its shelf life. The hands-on-experience will yield synergistic information/quality in future high-tech ventures in chemical sciences. A select set of current literature reports from ACS (American chemical society) dealing with proved benefit of Seed methods in diverse disciplines involving chemical species follow. The chosen display format is to browse through the crisp information fast and not dilating into hierarchical details. The target readers are researchers to appreciate the high potency of the tool in the arsenal of research methodology. The experts in one field may be inspired to think of its use in their field to extract increased amount of information with relatively less number of experiments.

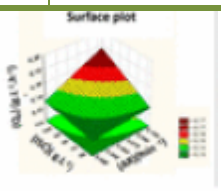
Factorial design (FD, FactDes)		
Task:	Response	Variables in ED
Rat MI (Myocardial infarction) model  Infarcted Myocardium Opt( multiple protein therapy)	☀ Ejection fraction 4 weeks after MI after injecting protein combination ☀ Factorial design	→ Tissue inhibitor of metalloproteinases 3 (TIMP-3) → Interleukin-10 (IL-10) → Basic fibroblast growth factor (FGF-2) → Stromal cell-derived factor 1 alpha (SDF-1 $\alpha$ )
Factorial Design of Experiments to Optimize Multiple Protein Delivery for Cardiac Repair ACS Biomater. Sci. Eng., 2016, 2 (5), pp 879–886 DOI: 10.1021/acsbiomaterials.6b00146 Hassan K. Awada, Louis A. Johnson, T. Kevin Hitchens, Lesley M. Foley, and Yadong Wang		

Expdes (ED)	Discipline	Variables in ED	Resp
Full factorial design	■ Biochemical Sugar Production from Switchgrass 	→ Temperature 140 to 180 °C; → Time 10 to 40 min; → Sulfuric acid 0.5% or 1% (v/v)	Ⓡ Prehydrolyzate xylose Ⓡ Glucose concentrations etc.

Three way factor interaction has significant influence on prehydrolyzate glucose concentrations

Effects of Dilute Acid Pretreatment Parameters on Sugar Production during Biochemical Conversion of Switchgrass Using a Full Factorial Design

ACS Sustainable Chem. Eng., 2016, 4 (8), pp 4124–4130; DOI: 10.1021/acssuschemeng.6b00441  
Angele Djiroleu and Danielle Julie Carrier

Expdes (ED)	Task	Variables in ED	Resp
2 <sup>2</sup> -full factorial design	<ul style="list-style-type: none"> <li>Hemicellulosic Ethanol Production in Fluidized Bed Reactor</li> </ul>	<ul style="list-style-type: none"> <li>Aeration rate (0.027, 0.069, and 0.111 min<sup>-1</sup>)</li> <li>carrier concentration (55.55, 83.33, and 111.11 g. L<sup>-1</sup>)).</li> </ul>	<ul style="list-style-type: none"> <li>On the ethanol yield (<math>Y_{P/S}</math>) and productivity (<math>Q_P</math>)</li> </ul>
			

Hemicellulosic Ethanol Production in Fluidized Bed Reactor from Sugar Cane Bagasse Hydrolysate: Interplay among Carrier Concentration and Aeration Rate

ACS Sustainable Chem. Eng., 2017, 5 (9), pp 8250–8259; DOI: 10.1021/acssuschemeng.7b01916  
Felipe A. F. Antunes, Anuj K. Chandel, Julio Cesar dos Santos, Thais S. S. Milessi, Guilherme F. D. Peres, and Silvio Silvério da Silva

Expdes (ED)	Variables in ED	Resp
Full factorial (2 <sup>4</sup> )	<ul style="list-style-type: none"> <li>pH</li> <li>Nps loading</li> <li>Initial drug concentration</li> <li>Contact time</li> </ul>	<ul style="list-style-type: none"> <li>Efficiency of adsorption of two photosensitive fluoroquinolones Ciprofloxacin (CIP) and Moxifloxacin (MOX) on the surface of synthesized magnetite/pectin nanoparticles</li> </ul>

Adsorptive Removal of Fluoroquinolones from Water by Pectin-Functionalized Magnetic Nanoparticles: Process Optimization Using a Spectrofluorimetric Assay

ACS Sustainable Chem. Eng., 2017, 5 (1), pp 133–145; DOI: 10.1021/acssuschemeng.6b01003  
Olivia A. Attallah, Medhat A. Al-Ghobashy, Marianne Nebsen, and Maissa Y. Salem

Task:	Resp	Variables in ED (X)
<p>Novel biomaterials are suitable for extrusion-based 3D printing applications. Poly(propylene fumarate) (PPF) as a model material</p> <p>ED: Full factorial design</p>	<p>Viscosity Fiber diameter And pore size Layer-by-layer on 3D scaffolds</p> <p>Viscoity = <math>\ln(\ln(\text{[PPF]}))</math></p>	<ul style="list-style-type: none"> <li>[PPF]</li> <li>Printing pressure,</li> <li>Printing speed</li> <li>Programmed fiber spacing</li> </ul>

Extrusion-Based 3D Printing of Poly(propylene fumarate) in a Full-Factorial Design ACS Biomater. Sci. Eng., 2016, 2 (10), pp 1771–1780

DOI: 10.1021/acsbiomaterials.6b00026

Jordan E. Trachtenberg, Jesse K. Placone, Brandon T. Smith, Charlotte M. Piard, Marco Santoro, David W. Scott, John P. Fisher, and Antonios G. Mikos

Expdes (ED)	Discipline	Reduce to
☼ Generalized fractional factorial design	<ul style="list-style-type: none"> <li>Multivariate calibration using microwave resonance spectroscopy for (a) determination of water in tablets, (b) stability study in drug product development (c) representative sample selection in clinical studies</li> </ul>	➔ Complementary and balanced sub designs analogous to a fold-over in two-level reduced factorial designs

Expdes (ED)	Discipline	Variables in ED	Resp
Factorial	<ul style="list-style-type: none"> <li>Renewable energy</li> </ul>	<ul style="list-style-type: none"> <li>➔ Compression ratio</li> <li>➔ Injection pressure</li> <li>➔ Injection timing</li> </ul>	Ⓜ Variable compression ratio

Fueled with Diesel–Aegle Marmelos Oil–Diethyl Ether Blends Using Response Surface Methodology

Energy Fuels, 2017, 31 (10), pp 11362–11376; DOI: 10.1021/acs.energyfuels.7b01515

M. Krishnamoorthi and R. Malayalamurthi

Expdes (ED)	Discipline	Variables in ED	Resp
Factorial design	<ul style="list-style-type: none"> <li>Adsorption</li> </ul>	<ul style="list-style-type: none"> <li>➔ Aptes concentration</li> <li>➔ reaction temperature and reaction duration</li> </ul>	Ⓜ Silica adsorbent BET surface area
<b>Software:</b> Minitab-15			

Benzene, Toluene, m-Xylene Adsorption on Silica-Based Adsorbents

Energy Fuels, 2017, 31 (2), pp 1882–1888; DOI: 10.1021/acs.energyfuels.6b03192

T. Ncube, K. Suresh Kumar Reddy, Ahmed Al Shoaibi, and C. Srinivasakannan

### Fractional Factorial design (Fr.FD, Fract.FactDes)

Expdes (ED)	Discipline	Variables in ED	Resp
☼ fractional factorial design	<ul style="list-style-type: none"> <li>MALDI-TOF-MS</li> </ul>	<ul style="list-style-type: none"> <li>➔ Matrix preparations</li> <li>➔ Matrix additives</li> <li>➔ Additive concentrations</li> <li>➔ Deposition</li> </ul>	Ⓜ Detection of Phospholipids and Acylglycerols

	methods
720 key experiments by FrFd instead of 8064 possible trials; Pareto optimality used	

### Fractional Factorial Design of MALDI-TOF-MS Sample Preparations for the Optimized Detection of Phospholipids and Acylglycerols

Anal. Chem., 2016, 88 (12), pp 6301–6308; DOI: 10.1021/acs.analchem.6b00512

Najla almasoud, Elon Correa, Drupad K. Trivedi, and Royston Goodacre

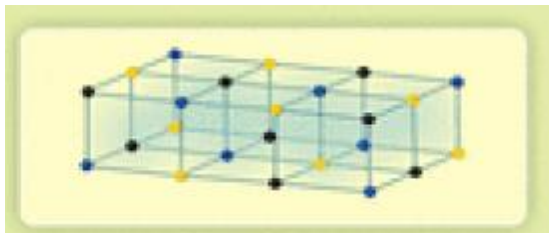
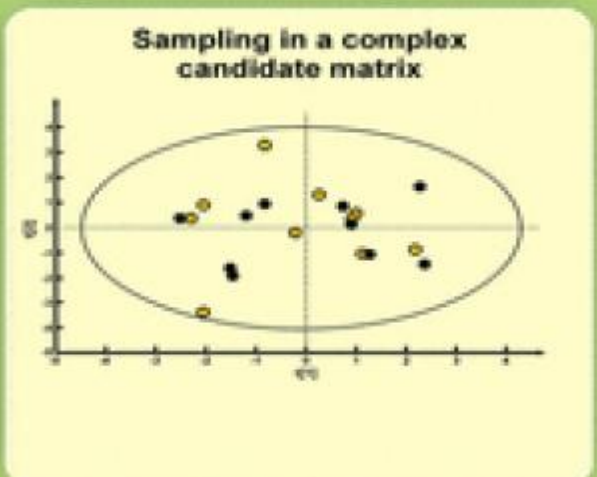
Expdes (ED)	Task	Variables in ED	Resp
$2^{5-1}$ factorial design	<ul style="list-style-type: none"> <li>■ Bioethanol Production</li> </ul>	<ul style="list-style-type: none"> <li>➔ Temperature (80–120 °C)</li> <li>➔ Solid loading (2.5–7.5%)</li> <li>➔ Glycerol (85–95%)</li> <li>➔ Acid concentrations (0.5–3%)</li> <li>➔ Reaction time (10–60 min),</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Glycerol acid-pretreatment of sugar cane bagasse</li> </ul>

### Organosolv Pretreatment of Sugar Cane Bagasse for Bioethanol Production

Ind. Eng. Chem. Res., 2017, 56 (14), pp 3833–3838

DOI: 10.1021/acs.iecr.7b00079

Ruly Terán Hilaes, Mateus Pereira Swerts, Muhammad Ajaz Ahmed, Lucas Ramos, Silvio Silvério da Silva, and Júlio César Santos

Generalized Fr FD	
	
	
Qualitative factors	Factor levels
Strength	[10mg, 40mg]
Container	[3;30;500;1000] ml
Batch	[Batch1; batch 2;batch 3]

### Generalized Subset Designs in Analytical Chemistry

Anal. Chem., 2017, 89 (12), pp 6491–6497; DOI: 10.1021/acs.analchem.7b00506

Izabella Surowiec, Ludvig Vikström, Gustaf Hector, Erik Johansson, Conny Vikström, and Johan Trygg

### Central Composite design (CCD, Central Comp. Desig.)

Expdes (ED)	Discipline	Process Variables in ED	Resp
Central composite design	Biodiesel	<ul style="list-style-type: none"> <li>➔ Reaction time</li> <li>➔ Methanol/oil ratio</li> <li>➔ Catalyst loading</li> </ul>	Ⓡ Biodiesel yield

#### Transesterification of Rubber Seed Oil to Biodiesel over a Calcined Waste Rubber Seed Shell Catalyst: Modeling and Optimization of Process Variables

Energy Fuels, 2017, 31 (6), pp 6109–6119; DOI: 10.1021/acs.energyfuels.7b00331

Samuel Erhigare Onoji, Sunny E. Iyuke, Anselm I. Igbafe, and Michael O. Daramola

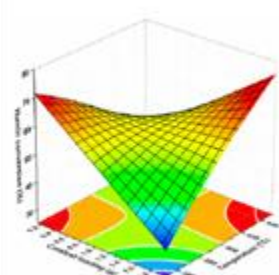
Expdes (ED)	Discipline	Variables in ED	Resp
Central composite	<ul style="list-style-type: none"> <li>▪ Synthesis</li> </ul>	<ul style="list-style-type: none"> <li>➔ Acetone to monoacetin mole ratio</li> <li>➔ Reaction temperature</li> <li>➔ pressure</li> <li>➔ Flow rate</li> <li>➔ Catalyst</li> </ul>	Ⓡ Yield of the second stage of the reaction

#### Optimization of Solketalacetin Synthesis as a Green Fuel Additive from Ketalization of Monoacetin with Acetone

Ind. Eng. Chem. Res., 2016, 55 (25), pp 6904–6910; DOI: 10.1021/acs.iecr.6b00929

Yadollah M. Gorji and Hassan S. Ghaziaskar

Expdes (ED)	Discipline	Variables in ED	Resp
Central composite (19 experiments)	<ul style="list-style-type: none"> <li>▪ Catalysis</li> </ul>	<ul style="list-style-type: none"> <li>➔ T</li> <li>➔ Humin intake</li> <li>➔ Catalyst intake</li> <li>➔ Batch time</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Humin conversion</li> <li>Ⓡ Alkylphenolics yield</li> </ul>



#### Catalytic Liquefaction of Humin Substances from Sugar Biorefineries with Pt/C in 2-Propanol

ACS Sustainable Chem. Eng., 2017, 5 (1), pp 469–480; DOI: 10.1021/acssuschemeng.6b01834

Y. Wang, S. Agarwal, and H. J. Heeres

Expdes (ED)	Variables in ED	Resp
<ul style="list-style-type: none"> <li>▪ Central composite</li> </ul>	<ul style="list-style-type: none"> <li>➔ Hydrotreating conditions</li> <li>➔ Temperature, pressure</li> </ul>	Ⓡ Fines deposition on nimo/γal2o3 catalyst

→ Particle loading

The Impact of Process Parameters on the Deposition of Fines Present in Bitumen-Derived Gas Oil on Hydrotreating Catalyst

Energy Fuels, 2017, 31 (6), pp 5969–5981; DOI: 10.1021/acs.energyfuels.7b00554

Rachita Rana, Sandeep Badoga, Ajay K. Dalai, and John Adjaye

Expdes (ED)	Discipline	Resp	Variables in ED	Optimum values
Central composite	Extraction	Extraction yield (7.9936 ± 0.0364 mg/g)	▪ Solvent/solid ratio	17.5:1
			▪ Ultrasonic power	180 W,
			▪ Temperature	45 °C,
			▪ Particle size	80 mesh
			▪ Extraction time	70 min

Well-Designed Hydrophobic Deep Eutectic Solvents As Green and Efficient Media for the Extraction of Artemisinin from *Artemisia annua* Leaves

ACS Sustainable Chem. Eng., 2017, 5 (4), pp 3270–3278; DOI: 10.1021/acssuschemeng.6b03092

Jun Cao, Meng Yang, Fuliang Cao, Jiahong Wang, and Erzheng Su

Expdes (ED)	Task:	Variables in ED [opt values]
Composite fractional factorial	Synthesis of gold nanorods	<p>Experimental factors</p> <ul style="list-style-type: none"> <li>→ Amount of sodium borohydride</li> <li>→ Rate of stirring when producing seed nanoparticles</li> <li>→ Age of and amount of seeds added</li> <li>→ Reaction temperature</li> <li>→ Amounts of silver nitrate</li> <li>→ Amount ascorbic acid added</li> <li>→ Age of reduced growth solution before seed nanoparticles are added to initiate rod formation</li> </ul>

Understanding the Seed-Mediated Growth of Gold Nanorods through a Fractional Factorial Design of Experiments

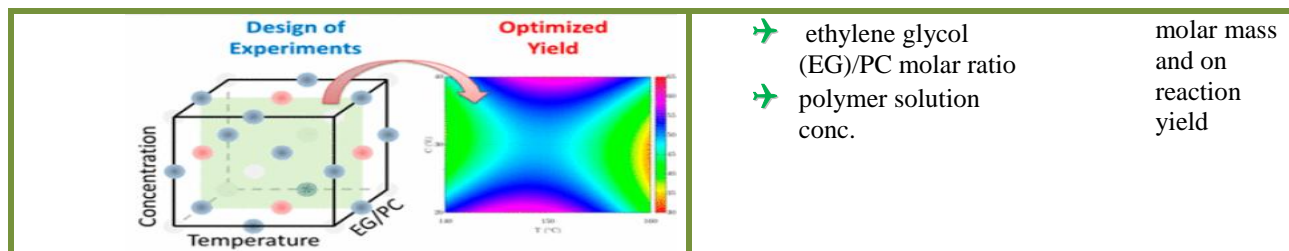
Langmuir, 2017, 33 (8), pp 1891–1907  
DOI: 10.1021/acs.langmuir.6b03606

Nathan D. Burrows, Samantha Harvey, Fred A. Idesis, and Catherine J. Murphy

### Box–Behnken

Expdes (ED)	Discipline	Variables in ED	Resp
Box–Behnken	▪ Synthesis	→ Temperature	® PC(OH) <sub>2</sub>





- ethylene glycol (EG)/PC molar ratio
  - polymer solution conc.
- molar mass and on reaction yield

### Telechelic Poly(bisphenol A carbonate) Synthesis by Glycolysis: A Response Surface Methodology Approach

Eng. Chem. Res., 2017, 56 (14), pp 3983–3992; DOI: 10.1021/acs.iecr.6b04614

Thiago do Carmo Rufino, Márcia Cristina Breikreitz, and Maria Isabel Felisberti

Expdes (ED)	Discipline	Variables in ED	Resp
<ul style="list-style-type: none"> <li>➤ Box-Behnken</li> <li>➤ Central composite</li> </ul>	<ul style="list-style-type: none"> <li>▪ Catalysis</li> </ul>	<ul style="list-style-type: none"> <li>➤ Methanol/oil ratio</li> <li>➤ Catalyst amount</li> <li>➤ Reaction time on,</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Acid value</li> <li>Ⓡ Biodiesel yield</li> </ul>
<ul style="list-style-type: none"> <li>✓ Scanning electron microscopy (SEM)</li> <li>✓ X-ray diffraction (XRD)</li> <li>✓ Fourier transform infrared (FTIR)</li> <li>✓ Elemental analysis</li> </ul>			

### Two-Step Conversion of Neem (*Azadirachta indica*) Seed Oil into Fatty Methyl Esters Using a Heterogeneous Biomass-Based Catalyst: An Example of Cocoa Pod Husk

Energy Fuels, 2017, 31 (6), pp 6182–6193; DOI: 10.1021/acs.energyfuels.7b00604

Eriola Betiku, Anietie Okon Etim, Omoniyi Perea, and Tunde Victor Ojumu

Expdes (ED)	Discipline	Variables in ED	Resp
Box–Behnken	<ul style="list-style-type: none"> <li>▪ Synthesis-- methyl acrylate</li> <li>▪ Fluidized Bed Reactor</li> </ul>	Process parameters <ul style="list-style-type: none"> <li>➤ Reaction temperature</li> <li>➤ Molar ratio of Ma and FA</li> <li>➤ Liquid hourly space velocity (LHSV)</li> </ul>	Yield

### One-Step Synthesis of Methyl Acrylate Using Methyl Acetate with Formaldehyde in a Fluidized Bed Reactor

Ind. Eng. Chem. Res., 2017, 56 (33), pp 9322–9330; DOI: 10.1021/acs.iecr.7b02522

Shifeng Jiang, Chunshan Li, Hongnan Chen, Dan Yang, and Suojiang Zhang

## Taguchi

Expdes (ED) Discipline	Variables in ED	Resp
Taguchi factorial design	<ul style="list-style-type: none"> <li>➤ ABP concentration</li> <li>➤ Acetone concentration</li> <li>➤ Volume ratio of acetone to ABP</li> <li>➤ Drug concentration</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Nanocarrier characteristics</li> <li>Ⓡ Particle size, polydispersity index, zeta potential, and percentage drug loading</li> </ul>

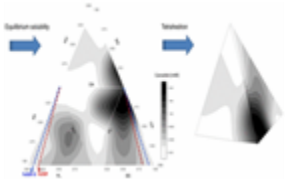


Factorial Design Based Multivariate Modeling and Optimization of Tunable Bioresponsive Arginine Grafted Poly(cystaminebis(acrylamide)-diaminohexane) Polymeric Matrix Based Nanocarriers

Mol. Pharmaceutics, 2017, 14 (1), pp 252–263; DOI: 10.1021/acs.molpharmaceut.6b00861

Rongbing Yang, Kihoon Nam, Sung Wan Kim, James Turkson, Ye Zou, Yi Y. Zuo, Rahul V. Haware<sup>∇</sup>, and Mahavir B. Chougule

### Mixture design

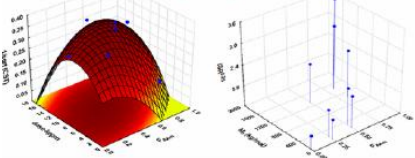
Expdes (ED)	Task	Variables in ED	Resp
Four-component mixture design Factorial design	<ul style="list-style-type: none"> <li>■ Solubility of drugs               <ul style="list-style-type: none"> <li>○ acidic (zafirlukast)</li> <li>○ basic (aprepitant, carvedilol)</li> <li>○ neutral (fenofibrate, felodipine, griseofulvin, and spironolactone)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>→ digested lipids</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Solubility variation</li> </ul>
			

Influence of Physiological Gastrointestinal Surfactant Ratio on the Equilibrium Solubility of BCS Class II Drugs Investigated Using a Four Component Mixture Design

Mol. Pharmaceutics, Article ASAP; DOI: 10.1021/acs.molpharmaceut.7b00354

Zhou Zhou, Claire Dunn, Ibrahim Khadra, Clive G. Wilson, and Gavin W. Halbert

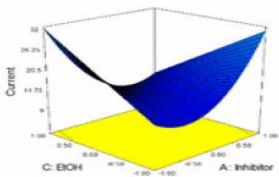
### Response Surface Methodology (RSM)

Expdes (ED)	Discipline	Variables in ED	Resp
RSM	<ul style="list-style-type: none"> <li>■ Polymers</li> </ul>	<ul style="list-style-type: none"> <li>→ Chemical composition</li> <li>→ Average molecular weight of poly(acrylamide-co-diallyldimethylammonium chloride) in</li> </ul>	<ul style="list-style-type: none"> <li>Ⓡ Dewatering mfts</li> </ul>
			

Dewatering Oil Sands Mature Fine Tailings (mfts) with Poly(acrylamide-co-diallyldimethylammonium chloride): Effect of Average Molecular Weight and Copolymer Composition

Ind. Eng. Chem. Res., 2017, 56 (5), pp 1256–1266; DOI: 10.1021/acs.iecr.6b04348

Vahid Vajhinejad, Rina Guillermo, and João B.P. Soares

Expdes (ED)	Resp		Variables in ED	Optimum values
RSM	Corrosion inhibition efficiency of 2-(2-hydroxyphenyl)-benzothiazole		■ Inhibitor concentration	433.7 $\mu\text{m}$
			■ Hydrochloric acid	3.38 M for
			■ Ethanol	0.36 M for

Experimental and Theoretical Investigation of Inhibition Efficiency of 2-(2-Hydroxyphenyl)-benzothiazole Using Impedance Spectroscopy, Experimental Design, and Quantum Chemical Calculations

Ind. Eng. Chem. Res., 2017, 56 (32), pp 9035–9044; DOI: 10.1021/acs.iecr.7b02030

Marzie Afzalkhah, Saeed Masoum, Mohsen Behpour, Hossein Naeimi, and Adel Reisi-Vanani

Typical books on experimental design (Seed)

Experimental Design and Analysis

<http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf> data files :

<http://www.stat.cmu.edu/~hseltman/309/Book/data/> **2015**

Howard J. Seltman,

Statistical Design and Analysis of Experiments, Chapters 7 to 10

Society for Industrial and Applied Mathematics Philadelphia, **1998**

Peter W. M. John

A First Course in Design and Analysis of Experiments, Chapters 18, 19.

ISBN 0-7167-3510-5, **2010**

Gary W. Oehlert

Design and Analysis of Experiments, Chapter s, 15 and 16.

Springer, New York, **1999**

Angela Dean, Daniel Voss,

Computer applications in chemistry Chapter 11: Experimental designs

Himalaya publishing House, 2005, Mumbai, India,

R Sambasiva Rao, G Nageswara Rao

The role of Simplex method in chemical research

J.Chem.Sci. 14(1993)23-44

Review: state-of-knowledge algorithms –applications kinetic method of analysis-chromatography-instrumental parameters

R. Sambasiva Rao

**Object Oriented Vocabulary of Design of Experiments (DOE)**  
**Statistical Evolving experimental design (stat.evol.expdes, SEED)**

Sampling points : statistical  
 XY\_Model : [Mathematical ; statistical; Fuzzy]  
 Objfn: [Mathematical ; statistical; Fuzzy]

	Goal: Opt(Fn{residual in response})
Expdes.Methods	[sample space; Response surface modelling; Prediction → Experiment ; refinement [ coarse; fine];]
Expdes.Applications	Optimum [Operating conditions [exptal variables]; Instrumental parameters;]
Optimum	[maximum ; Minimum;]
\$\$\$ _Design	[single variable; Multiple variable;]
Multiple variables:	[one variable at a time (OVAT); Multiple variables at a time (MVAT); [Sequential ; Parallel;] [one method; Hybrid [binary; ternary;]
Uniform	
Factorial	: [mixed; fractional; confounded ] [full ; Fractional; Central composite]
Fractional factorial	:
Central composite	: [simple; with star points]
Orthogonal	: [Plackett-Burma Box Behnken
\$\$\$ optimal designs	: [A ; D; E;]
Hybrid	[factorial + simplex] [factorial + random] [factorial + random + simplex]

Mixture	
Simplex	[Basic; Modified simplex; Super modified simplex;
Taguchi design	
Surrogate-Enhanced Evolutionary Annealing-Simplex (SEEAS)	[evolutionary search + simulated annealing + downhill simplex)
Model ;	[multiple-linear; Multiple-linear with cross products; Multiple-polynomial [ square; cubic; quatic]; Full quadratic; Full polynomial]; Neural networks
Stochastic response surface method (Stochast.RSM)	[non-Gaussian dependent random variables used under incomplete probability information]
Model.objective	Prediction of extremum in m-D space of experimental variables Objective: (optimum) Parametrization but not curve fitting