

## Physical Sciences

- Geology, Geochemistry and Geotectonic Setting of the Pan-African Granites and Charnockites Around Ado-Ekiti, Southwestern Nigeria  
Akindele O. Oyinloye and Romanus Obasi 299
- Effect of Excess Metal Concentration on the Extraction Potential of Di-(2-Ethylhexyl) Phosphoric Acid  
A. S. Ahmed, M. B. Bhatti, M. T. Saeed and S. K. Afridi 309
- Evaluation of Locally Available Fuller's Earth for the Bleaching of Soybean Oil  
M. Sharif Nizami and M. Iqbal Chaudhry 314
- Studies on the Laboratory Scale Synthesis of 4, 4'-Diaminodiphenylurea and Preparation of Direct Dyes from the Compound  
S. Rehman Khan, A. M. Gilani, Asma Inayat and Shaheena Waheed 319
- Synthesis and Fungicidal Activity of Some Sulphide Derivatives of O-Ethyl-N-Substituted Phenylcarbamates  
F. Adelowo-Imeokparia and I. A. O. Ojo 324
- Isolation and Characterization of *Kappa*-Carrageenan from *Hypnea musciformis* (Red Alga) Collected from Karachi Coast, Pakistan  
Fatima Bi, Muhammad Arman, Mahmood-ul-Hassan and Seema Iqbal 330
- Comparative Studies on the Adsorption Properties of Powdered Activated Carbon and Propenoic Acid Modified Sawdust in the Treatment of Secondary Palm Oil Mill Effluent  
M. O. Osuide, C. M. A. Ademoroti, V. U. Okojie and F. E. Igbinavbiere 335

## Short Communication

- Some Studies on the Changes in the Composition of Coal Ash and Bottom/Fly Ash Produced in Atmospheric Fluidized Bed Combustor  
Ismat Ali and M. Mohsin Ali 341

## Biological Sciences

- High Frequency *In vitro* Propagation of *Polianthes tuberosa*  
Muhammad Saeed Ahmad, Tauqeer Ahmad, Nasreen Zaidi and Idress Ahmad Nasir 344
- Morphological Changes in Cotton Roots in Relation to Soil Mechanical Impedance and Matric Potential  
Ghulam Nabi and C. E. Mullins 349

<b>Multiple Parameters for Ascertaining Yield Stability of Upland Cotton Varieties Tested Over Number of Environments</b> Muhammed Jurial Baloch and Nasreen Fatima Veesar	<b>355</b>
---	------------

## **Technology**

<b>Isolation and Stabilization of Dark Red Food Dye from <i>Beta vulgaris</i></b> Alim-un-Nisa, Shamma Firdous and Nusrat Ijaz	<b>360</b>
---	------------

<b>The Effect of Substitution on the Dyeing and Spectroscopic Properties of Some Monoazo Disperse Dyes</b> Ausaf Aleem, Mohammad Naeem, M. Aleem Ahmed, Kamran Ahmed and Mansoor Iqbal	<b>364</b>
---	------------

<b>Physicochemical Characteristics of Rayon Grade Dissolving Pulp and the Effects of Metallic-Ions on the Viscose Rayon Process</b> Atif Latif, Asad Ullah Jan, Farid Ullah Khan and Amin Ur Rahman	<b>368</b>
--	------------

## **Short Communication**

<b>The Study of Electrolytes on the Dye Uptake of Bifunctional Reactive Red Dyes on a Cellulosic Substrate (Cotton K-68)</b> Javaid Mughal, Ausaf Aleem, Qasim Siddiqui and Mansoor Iqbal	<b>371</b>
--	------------

# Geology, Geochemistry and Geotectonic Setting of the Pan-African Granites and Charnockites Around Ado-Ekiti, Southwestern Nigeria

Akindele O. Oyinloye<sup>a\*</sup> and Romanus Obasi<sup>b</sup>

<sup>a</sup>Department of Geology, University of Ado-Ekiti, PMB-5363, Ado-Ekiti, Nigeria

<sup>b</sup>Department of Mineral Resources Engineering, Federal Polytechnic, Ado-Ekiti, Nigeria

(received April 8, 2006; revised August 21, 2006; accepted September 19, 2006)

---

**Abstract.** The geology, petrology and geochemistry of the coarse-grained and fine-medium-grained gneissic charnockites and the porphyritic biotite-hornblende and medium-grained older granites in the Ado-Ekiti area were studied. Xenoliths of schistose quartzite occur within these charnockitic and granitic rocks. The porphyritic older granite and the coarse-grained charnockite occur in very close association in the field. All these rocks contain monazite, in their mineralogical composition, which indicate crustal input into their original magma. Aluminium-total iron-magnesium (AFM) plot for these rocks indicated that they were calc-alkaline in nature and were formed in a subduction related tectonic setting. Percentage normative corundum versus mol.  $Al_2O_3/(Na_2+K_2O+CaO)$  plots for the older granites and the charnockites from the Ado-Ekiti area revealed that their original magma was derived from a mixed source (igneous and crustal). Y+Nb versus Rb plots for the older rare earth granites and the charnockites indicated that they originated from a volcanic arc and within-plate environments. The normalised rare earth elements (REE) patterns showed that these rocks were genetically related, and the feldspar fractionation took place during their formation as revealed by Eu depletion patterns in the REE diagrams. The negative  $Eu/Eu^*$  (ratio of absolute europium to normalized europium) anomaly and  $(La/Yb)_N$  ratios higher than 5 obtained in these rocks indicated that they were emplaced through magmatic fractionation. The mixed magma from which these rocks were derived was formed in a back arc tectonic setting where an ocean slab was subducted into the mantle leading to the generation of magma, which intruded into the earlier formed rocks in a back arc basin. The charnockites and the older granites were the end products of the differentiation of such magma.

**Keywords:** monazite, xenolith, calc-alkaline, subduction, southwestern Nigeria, geotectonic setting, Pan-African granites, charnockites

---

# Effect of Excess Metal Concentration on the Extraction Potential of Di-(2-Ethylhexyl) Phosphoric Acid

A. S. Ahmed\*, M. B. Bhatti, M. T. Saeed and S. K. Afridi

Glass and Ceramics Research Centre, PCSIR Laboratories Complex, Ferozpur Road, Lahore-54600, Pakistan

(received April 19, 2005; revised August 30, 2006; accepted September 2, 2006)

---

**Abstract.** The extraction potential of di-(2-ethylhexyl) phosphoric acid (DEHPA) in kerosene increases manifold on loading calcium into the organic phase before equilibration with aqueous copper feed. The control of pH was unnecessary in the range from pH 5.0 to pH 3.0. It was found that copper can easily replace nickel, sodium and calcium in the organic phase because of the difference in the dissociation constants of copper and other metals studied. The hydrolysis of calcium maintains the pH of the aqueous phase in favour of higher extraction of copper by DEHPA.

**Keywords:** dissociation constant, di-(2-ethylhexyl) phosphoric acid, copper extraction

---

# Evaluation of Locally Available Fuller's Earth for the Bleaching of Soybean Oil

M. Sharif Nizami\* and M. Iqbal Chaudhry

PCSIR Laboratories Complex, Ferozepur Road, Lahore-54600, Pakistan

(received February 4, 2005; revised June 24, 2006; accepted June 27, 2006)

---

**Abstract.** Locally available Fuller's earth was investigated for bleaching soybean oil. Investigations showed that raw earth samples possessed desirable physical properties and consisted of the clay minerals suitable for bleaching edible oils. The Fuller's earth sample was also activated by refluxing with 4 N hydrochloric acid for 3 h at 100 °C. Fresh volumes of soybean oil were bleached with 3% of the activated earth and its bleachability was determined by Lovibond tintometer. The efficiency of bleachability was compared with that of Tarana Optimum, the standard bleaching earth of German origin for comparison. It was found that bleachability of the activated earth samples and that of Tarana Optimum was quite comparable.

**Keywords:** oil bleachability, Fuller's earth, soybean oil, Fuller's earth activation

---

# Studies on the Laboratory Scale Synthesis of 4,4'-Diaminodiphenylurea and Preparation of Direct Dyes from the Compound

S. Rehman Khan\*, A. M. Gilani, Asma Inayat and Shaheena Waheed

Leather Research Section, Applied Chemistry Research Centre, PCSIR Laboratories Complex, Ferozpur Road,  
Lahore-54600, Pakistan

(received October 20, 2005; revised October 3, 2006; accepted October 3, 2006)

---

**Abstract.** 4,4'-Diaminodiphenylurea has been synthesized as a potential replacement for benzidine by reaction between *p*-phenylenediamine and urea under different catalytic and reaction conditions. Reaction conditions have been optimized to obtain maximum yield of intermediates. Direct dyes have been prepared from the title compound. The synthesized dyes were used to dye cotton and leather and the colour fastness properties of the dyed cotton and leather were assessed. Results showed that the synthesized dyes have fair to good fastness properties for cotton.

**Keywords:** 4,4'-diaminodiphenylurea, benzidine substitute, direct dyes

---

## Synthesis and Fungicidal Activity of Some Sulphide Derivatives of O-Ethyl-N-Substituted Phenylcarbamates

F. Adelowo-Imeokparia<sup>a\*</sup> and I. A. O. Ojo<sup>b</sup>

<sup>a</sup> Department of Pure and Applied Chemistry, Ladoko Akintola University of Technology, Ogbomosho, Nigeria

<sup>b</sup> Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria

(received March 14, 2006; revised September 12, 2006; accepted September 19, 2006)

---

**Abstract.** Monosulphides of O-ethyl-N-substituted phenylcarbamates were prepared by the reaction between O-ethyl-N-substituted phenylcarbamates and sulphur dichloride, while the corresponding disulphides were prepared by the reaction between O-ethyl-N-substituted phenylcarbamates and sulphur monochloride. The synthesized compounds were characterized by elemental analysis, thin layer chromatography (TLC), Fourier-transform infrared, and <sup>1</sup>H and <sup>13</sup>C nuclear magnetic resonance spectroscopic techniques. *In vitro* fungicidal assay of these sulphides against *Fusarium oxysporum*, *Aspergillus niger*, *Aspergillus flavus* and *Rhizopus stolonifer* showed that they had greater fungicidal activity than their parent carbamates. The synthesized sulphides were more active towards *A. niger* and *A. flavus*. Unlike the parent carbamates, the type of substituents attached to the aromatic nucleus of these sulphides had little or no effect on their fungicidal activity as there was insignificant variation in the fungicidal activity of the monosulphide and the disulphide derivatives of O-ethyl-N-substituted phenylcarbamates.

**Keywords:** fungicidal activity, sulphide derivatives, O-ethyl-N-substituted phenylcarbamate, fungicides, organosulphur compounds

---

## Isolation and Characterization of *Kappa*-Carrageenan from *Hypnea musciformis* (Red Alga) Collected from Karachi Coast, Pakistan

Fatima Bi\*, Muhammad Arman, Mahmood-ul-Hassan and Seema Iqbal

Pharmaceutical Research Centre, PCSIR Laboratories Complex Karachi,

Sharah-e- Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan

(received January 18, 2006; revised June 20, 2006; accepted June 27, 2006)

---

**Abstract.** *Hypnea musciformis*, collected from Karachi coast of Pakistan, was used for the isolation of a thickening and emulsifying agent, carrageenan. Various extraction procedures were employed and the yield of carrageenan obtained was in the range of 34-44%. Total sugar contents were found to be 31.8-55.4%. 3,6-Anhydrogalactose, a component of the total sugar, was present in the range of 19.9-27.6%. Sulphate and ash contents were high, 14.8-41% and 15.4-53%, respectively. The positive rotation of these polysaccharides indicated a predominance of  $\alpha$ -D-glycosidic linkages in their structure. IR spectral studies showed *kappa*-carrageenan as the major phycocolloid, with a very small contamination of *iota*-type carrageenan, whereas *lambda*-type was not detected. Polysaccharides obtained showed a positive elicitor activity in garden peas (*Pisum sativum*). HPLC analysis indicated the presence of a single major component.

**Keywords:** carrageenan, Rhodophyta, polysaccharides, elicitor activity, *Hypnea musciformis*, phycocolloid

---



# Comparative Studies on the Adsorption Properties of Powdered Activated Carbon and Propenoic Acid Modified Sawdust in the Treatment of Secondary Palm Oil Mill Effluent

M. O. Osuide<sup>a\*</sup>, C. M. A. Ademoroti<sup>b</sup>, V. U. Okojie<sup>a</sup> and F. E. Igbnavbiere<sup>a</sup>

<sup>a</sup>Department of Chemistry, Ambrose Alli University, Ekpoma, Nigeria

<sup>b</sup>Department of Chemistry, University of Benin, Benin City, Nigeria

(received December 28, 2004; revised July 18, 2006; accepted July 22, 2006)

---

**Abstract.** Propenoic acid monomer was used to modify pulped cellulosic materials (sawdust). The sorption properties of the propenoic acid modified sawdust (PAMS) were compared with those of powdered activated carbon (PAC) in the tertiary treatment of palm oil mill effluent, previously clarified with iron(III) chloride plus lime (secondary effluent). The adsorption processes were effected in a fluidized bed reactor (FBR) at a pressure of 80 kiloNewton per meter square (kNm<sup>2</sup>). Optimum amount of PAC and PAMS used for the fluidized adsorption of contaminants from the secondary palm oil mill effluent (POME) were 2.5 g/l and 4.0 g/l, respectively. These sorption processes were found to be optimum at 10 min and 50 min for PAC and PAMS, respectively. At optimum sorption conditions, removal differentials of 28.6%/g chemical oxygen demand, 19.1%/g suspended solids, and 19.3%/g colour in favour of PAC were established. The application of optimum conditions for adsorption, for both adsorbents, to the bulk treatment of the palm oil mill effluent yielded a clear effluent with wider reuse applicability.

**Keywords:** metal adsorption, palm oil mill effluent, propenoic acid treated sawdust, fluidized bed reactor, activated carbon, wastewater treatment

---

## Short Communication

# Some Studies on the Changes in the Composition of Coal Ash and Bottom/Fly Ash Produced in Atmospheric Fluidized Bed Combustor

**Ismat Ali\* and M. Mohsin Ali**

Fuel Research Centre, PCSIR, Shahrah-e-Dr. Salimuzzman Siddiqui, Karachi-75280, Pakistan

(received October 26, 2004; revised November 16, 2005; accepted November 19, 2005)

---

**Abstract.** A study on the ash of Lakhra lignite coal and the bottom/fly ash, obtained from combustion of Lakhra lignites in atmospheric fluidized bed combustor (AFBC) was carried out. It has been observed that the absence of alkali metals was of significant importance, as alkali metals were responsible for agglomeration in the AFBC.

**Keywords:** atmospheric fluidized bed combustion, coal energy, environmental pollution, coal, Lakhra lignites

---

## High Frequency *In vitro* Propagation of *Polianthes tuberosa*

Muhammad Saeed Ahmad, Tauqeer Ahmad, Nasreen Zaidi\* and Idrees Ahmad Nasir  
Plant Biotechnology Laboratory, Food and Biotechnology Research Centre, PCSIR Laboratories Complex,  
Ferozepure Road, Lahore-54600, Pakistan

(received February 7, 2006; revised September 9, 2006; accepted September 19, 2006)

---

**Abstract.** Calli induced on MS medium supplemented with 10  $\mu\text{M}$   $\alpha$ -naphthaleneacetic acid (NAA) grew extensively when cultured on MS medium modified with 4  $\mu\text{M}$  2,4-dichlorophenoxyacetic acid (2,4-D), producing on an average four shoots per callus culture. The addition of 1 mM L-arginine in the culture media enhanced the induction rate upto 10 shoots per callus culture in 12 weeks. When 2-3 cm long regenerated shoots were replanted on MS medium with 20  $\mu\text{M}$  6-benzylyadenine (BA) and 4  $\mu\text{M}$  2,4-D, shoots the proliferated at the cut ends. Floral axis buds produced 3-4 cm long multiple shoots on NAA and BA. New shoots regenerated from the calli produced at the base of shoots subcultured on 10  $\mu\text{M}$  NAA. Repetition of shoot development, callus formation, and again shoot formation on 10  $\mu\text{M}$  NAA and 2  $\mu\text{M}$  BA greatly increased the number of plants from single shoots. Eighty five percent bulb explants produced 290 shoots in 12 weeks directly on 15  $\mu\text{M}$  BA and 5  $\mu\text{M}$  NAA. The somatic psuedoembryos formed in the calli were dormant.

**Keywords:** L-arginine, clonal propagation, *Polianthes tuberosa*, tuberose plant

---

# Morphological Changes in Cotton Roots in Relation to Soil Mechanical Impedance and Matric Potential

Ghulam Nabi<sup>a\*</sup> and C. E. Mullins<sup>b</sup>

<sup>a</sup>Land Resources Research Programme, National Agricultural Research Centre, Islamabad-45500, Pakistan

<sup>b</sup>Department of Plant and Soil Science, Cruickshank Building, University of Aberdeen, AB24 3UU, UK

(received July 15, 2005; revised August 12, 2006; accepted September 5, 2006)

---

**Abstract.** Soil mechanical impedance (MI) and matric potential can both cause reduction in the root growth rate, modify rooting pattern and root diameter. Cotton seedlings are sensitive to the soil physical environment, particularly during early stages of growth. Soil matric potential and MI effect on root biomass, axial root length and diameter, and the number and length of lateral roots in soil packed to penetration resistances (PR) of 0.1, 1.0, 1.1 and 1.2 MPa (megaPascal =  $10^6$  Pascal), each at three matric potentials of  $-10$ ,  $-100$  and  $-500$  kPa (kiloPascal =  $10^3$  Pascal), were determined. Total root lengths were reduced by 29, 50 and 53% at impedance of 1.0, 1.1 and 1.2 MPa, respectively, as compared to the control, whereas MI of 1.2 MPa resulted in 60% reduction in axial root length. A similar increase in diameter was caused by increasing mechanical impedance, while decreasing matric potential had little effect. Roots that were water stressed did not change their diameter but had a shorter axis and longer lateral length. In contrast, the impeded roots (PR = 1.0, 1.1 and 1.2 MPa) had both a shorter axis and a smaller total length, but had increased diameter. These results not only illustrate the plasticity of root response to stress but also demonstrate how the response differs between different types of stresses.

**Keywords:** soil mechanical impedance, soil matric potential, root plasticity, root length, penetration resistance, soil physical environment

---

# Multiple Parameters for Ascertaining Yield Stability of Upland Cotton Varieties Tested Over Number of Environments

Muhammed Jurial Baloch\* and Nasreen Fatima Veesar

Department of Plant Breeding and Genetics, Sindh Agriculture University,  
Tandojam, Sindh, Pakistan

(received October 5, 2005; revised August 16, 2006; accepted August 29, 2006)

---

**Abstract.** Thirteen upland cotton varieties were evaluated in 12 different environments of the Sindh province, Pakistan, so as to arbitrate their stability in yield performance. The regression coefficient (**b**) parameter was used as a measure of varietal adaptability, whereas the sum of squared deviations from regression (**s<sup>2</sup>d**) and coefficient of determination (**r<sup>2</sup>**) were implied as the measure of stability. The regression coefficients (**b**) of all the varieties, though did not deviate significantly from a unit slope (**b** = 1.0), yet varieties FH-1000, VH-142, BH-147 and FH-945 exhibited (**b**) values very close to a unit slope suggesting their better adaptation to the test environments. Varieties CRIS-467, DNH-57 and FH-945 displayed lower **s<sup>2</sup>d** and higher **r<sup>2</sup>** values implying that these varieties were relatively more stable in yield performance than others in the test environments. Generally, not all the stability and adaptability parameters simultaneously favoured the same variety except FH-945, which was thus considered more stable, based on majority of the parameters. Principal component analysis (**PCA**) revealed that latent vectors of first two components, i.e., **PCA-1** and **PCA-2** accounted for about 91.24 % of the total variation. The eigen vectors of first **PCA-1** were smaller and all were positive, which further suggested that the test varieties were quite adaptive to all the test sites. However, in **PCA-2**, some varieties gave positive and some negative eigen values, yet varieties FH-1000, CIM-499, CRIS-467 and FH-945 expressed smaller and positive **PCA-2** scores suggesting less genotype-environment interactions for these particular varieties.

**Keywords:** stability and AMMI analysis, genotype-environment interaction, upland cotton varieties, environmental index, multivariate analysis

---

## Isolation and Stabilization of Dark Red Food Dye from *Beta vulgaris*

Alim-un-Nisa\*, Shamma Firdous and Nusrat Ijaz

Food and Biotechnology Research Centre, PCSIR Laboratories Complex, Ferozpur Road, Lahore-54600, Pakistan

(received August 25, 2005; revised June 30, 2006; accepted July 6, 2006)

---

**Abstract.** Natural highly coloured dark red pigment was isolated from *Beta vulgaris*, in paste and powdered form. Total colouring matter of the concentrated colour was 1.86% and 4.5%, respectively, for the paste and powdered forms, calculated as betanine. Sodium benzoate (0.01%) was used as the stabilizer for paste, while silicon dioxide (2%) was added in addition to sodium benzoate (0.01%) for storage of the red colour in powdered form. Other parameters that may influence the stability of the colour, such as pH, temperature and relative humidity, were studied. Toxicity evaluation, and lead and arsenic levels were determined. The addition of stabilizers, like citric acid, ascorbic acid, EDTA and sodium chloride, were also investigated, none of which showed useful effect.

**Keywords:** food colour, betanine, beetroot colour, *Beta vulgaris* red colour, food colour isolation, food colour stabilization

---

# The Effect of Substitution on the Dyeing and Spectroscopic Properties of Some Monoazo Disperse Dyes

**Ausaf Aleem\*, Mohammad Naeem, M. Aleem Ahmed, Kamran Ahmed and Mansoor Iqbal**

Applied Chemistry Research Centre (Textile Section), PCSIR Laboratories Complex Karachi,  
Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan

(received December 17, 2005; revised August 6, 2006; accepted August 9, 2006)

---

**Abstract.** A range of monoazo disperse dyes has been synthesized. The colour, dyeing and fastness properties of the dyes on polyester, nylon and secondary acetate fibre at 1/1 standard depth have been examined and rationalized in terms of dye structure. The visible absorption behaviour of the dyes was also investigated. In general, substitutions on the diazo component have a significant effect on the visible absorption maxima of the dyes. Increasing the solvent polarity also had a pronounced effect on the absorption maxima.

**Keywords:** monoazo dyes, diazotization, dyeing, dye migration

---

## Physicochemical Characteristics of Rayon Grade Dissolving Pulp and the Effects of Metallic-Ions on the Viscose Rayon Process

Atif Latif\*, Asad Ullah Jan, Farid Ullah Khan and Amin Ur Rahman

PCSIR Laboratories Complex, Jamrud Road, Peshawar-25120, Pakistan

(received May 5, 2005; revised July 31, 2006; accepted August 2, 2006)

---

**Abstract.** Pakistan imports rayon grade pulp from different countries for viscose rayon fibre manufacturing. Samples of imported pulp were collected and analyzed for alpha-cellulose, hemicellulose, calcium, magnesium, silica, copper, manganese, and iron. Moisture, ash content, cuprammonium viscosity, degree of polymerization, alkali absorption, and colour brightness were also determined. The results showed that all these parameters varied from sample to sample. The cotton linter pulp contained high alpha-cellulose content (94-98%) as compared to the softwood pulp (89.7-95%). Degree of polymerization of all samples was above 500 and varied from 500-750 ml/g. The study showed that higher manganese and copper content in cotton decreased the degree of polymerization. Iron above the standard value (7-10 ppm) affected the brightness of fibre, as observed in the case of cotton linter pulp (imported from China). The percentage of ash was less than 0.25% in all the samples studied.

**Keywords:** rayon pulp, pulp characteristics, metallic ion effects, viscose, rayon fibre, viscose process, dissolving pulp

---



## Short Communication

Pak. J. Sci. Ind. Res. 2006 49(5) 371-372

# The Study of Electrolytes on the Dye Uptake of Bifunctional Reactive Red Dyes on a Cellulosic Substrate (Cotton K-68)

**Javaid Mughal, Ausaf Aleem\*, Qasim Siddiqui and Mansoor Iqbal**

Applied Chemistry Research Centre (Textile Section), PCSIR Laboratories Complex Karachi,  
Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan

(received December 19, 2005; revised September 12, 2006; accepted September 14, 2006)

---

**Abstract.** For obtaining optimum conditions for dyeing a cellulosic substrate (cotton K-68) with bifunctional reactive dyes, it was investigated as to how the dyeing results depended upon the properties of the dyes and the substrate. A cellulosic substrate (cotton K-68) was dyed by varying the nature and quantity of electrolytes. Experimental findings indicated that sodium chloride and sodium sulphate produced good dye exhaustion. An increase in the concentration of electrolytes (sodium chloride, sodium sulphate and potassium chloride) also improved the fastness properties of the dyed substrate.

**Keywords:** cellulose dyeing, dye exhaustion, dye uptake

---