

CONTENTS

| | |
|---|----|
| Preface | v |
| <i>Chapter 1.</i> Introduction | |
| Historical | 1 |
| ■ Dyeing | 3 |
| Printing | 5 |
| References | 7 |
| <i>Chapter 2.</i> Machines for dyeing | |
| Loose stock dyeing | 9 |
| Yarn dyeing | 11 |
| Hank dyeing | 11 |
| Package dyeing | 13 |
| Fabric dyeing | 15 |
| The winch | 15 |
| The jig | 16 |
| Beamdyeing | 18 |
| Padding techniques | 19 |
| The Standfast process | 20 |
| Liquid boosters | 22 |
| Jet dyeing machine | 22 |
| ✓ Importance of physical properties of fibres | 23 |
| References | 26 |
| <i>Chapter 3.</i> Specification of dyeing properties | |
| Practical data | 28 |
| Tests devised by the Society of Dyers and Colourists | 30 |
| Direct cotton dyes | 31 |
| Wool dyes | 32 |
| Vat dyes | 34 |
| ✓ Disperse dyes | 37 |
| Basic dyes on acrylic fibres | 38 |
| ✓ Rates of dyeing at a single temperature | 39 |
| ✓ Disperse dyes | 42 |
| Direct dyes | 44 |
| Vat dyes | 48 |

| | |
|---|-----|
| Acid dyes' | 49 |
| Wool, 49 - Nylon, 49 | |
| Effect of denier on dyeing rate | 51 |
| References | 52 |
| <i>Chapter 4.</i> Physical methods | 55 |
| Dye estimation and purification | 55 |
| Optical estimations | 55 |
| ✓ Laws of light absorption | 57 |
| Purification of dyes | 59 |
| Dyeing measurements | 61 |
| References | 65 |
| <i>Chapter 5.</i> Non-ionic dyes. Equilibrium studies | 67 |
| Classification of dyeingsystems | 67 |
| disperse dyes | 68 |
| Importance of particle size | 70 |
| Dye solubility | 71 |
| Dyeing of cellulose acetate | 74 |
| ✓ Mechanism of dye transfer | 74 |
| Mechanism of dyeing | 78 |
| Printing systems | 84 |
| Energetics of dyeing | 84 |
| Changes in temperature | 90 |
| Cellulose triacetate | 92 |
| Heat setting | 93 |
| Mechanism of dyeing | 95 |
| Importance of acetyl content | 97 |
| Polyethylene terephthalate | 100 |
| Heat setting | 102 |
| Mechanism of dyeing | 103 |
| Nylon | 107 |
| Mechanism of dyeing | 108 |
| Acrylic fibres | 112 |
| Adsorption isotherms | 114 |
| ✓ The adsorption of disperse dyes by cellulose | 114 |
| ✓ Adsorption of disperse dyes by wool | 115 |
| Dyeing with water-soluble dyes | 115 |
| Energetics of dyeing | 120 |
| ✓ Absorption of mixtures of disperse dyes | 123 |
| ✓ Dyeing from the vapour phase | 128 |
| ✓ Heats of dyeing | 131 |

| | |
|---|-----|
| Determination of vapour pressure and heats of sublimation | 134 |
| Mode of attachment of dye | 135 |
| References | 140 |
| | |
| Chapter 6. Kinetics of dyeing of disperse dyes | 143 |
| Rates of dyeing | 143 |
| Diffusion of disperse dyes into fibres and films | 145 |
| Diffusion processes | 147 |
| Determination of <i>D</i> | 149 |
| Dye distribution in a non-steady state | 150 |
| Analysis of data. 150 – Comparison of theoretical and experimental profiles. 154 | |
| Measurement of diffusion coefficients from rate of dyeing . | 158 |
| (a) Initial rates. 158 – (b) Rates of dyeing. 159 – (c) Calculations using finite dyebaths. 164 – Measurements using desorption. 168 – Steady-state diffusion. 169 – Diffusion from the vapour phase. | |
| 175 | |
| Effects of temperature | 177 |
| Effect of changing acetyl value in cellulose acetates | 180 |
| Dyeing in admixture | 181 |
| Relation between affinity and diffusion coefficient | 183 |
| References | 188 |
| | |
| Chapter 7. Thermofixation of disperse dyes. | 191 |
| Padding | 191 |
| Fixation | 192 |
| Mechanism of dyeing | 192 |
| Dyeing of blends or union fabrics | 193 |
| Mechanism of dyeing blended or union fabrics | 194 |
| Energetics | 200 |
| References | 202 |
| | |
| Chapter 8. Dyeing of wool with acid dyes | 203 |
| The nature of dye solutions | 205 |
| Importance of wool structure | 207 |
| Dyeing of wool with acid dyes | 207 |
| Mechanism of the dyeing of wool | 209 |
| Adsorption of acids and bases by wool | 209 |
| Analysis of the titration curve | 215 |
| Langmuir, 216 – Donnan theory. 222 | |
| Adsorption of mixtures of acids | 236 |
| Adsorption of weak acids | 237 |
| Temperature effects | 238 |

| | |
|--|-----|
| Mechanism of acid dyeing | 240 |
| Adsorption isotherms of monobasic dyes. | 240 |
| Adsorption of the free dye acids, 243 — Isotherms where the dye concentration remains constant, 249 — Isotherms at constant dye-bath pH, 251 | |
| Adsorption in excess of amine groups | 252 |
| Action of electrolytes | 253 |
| Distribution of inorganic ions in the presence of dye | 253 |
| Neutral dyeing | 255 |
| Polybasic ions | 256 |
| Analysis of the adsorption isotherm | 257 |
| Langmuir, 257 — Donnan, 259 | |
| Measurement of affinity | 260 |
| From titration with the free acid | 260 |
| By desorption with inorganic ions | 260 |
| Langmuir, 260 — Donnan membrane, 263 | |
| Heats and entropies of dyeing | 270 |
| Dyeing in admixture | 270 |
| References | 272 |
| Chapter 9. Kinetics of wool dyeing | 275 |
| Level dyeing of wool | 275 |
| Diffusion coefficients | 277 |
| Diffusion through keratin membranes | 281 |
| Effects of a surface barrier | 285 |
| Dyeing of damaged wool | 291 |
| References | 293 |
| Chapter 10. The adsorption of acids and acid dyes by nylon | 295 |
| Dyeing of nylon with acid dyes | 295 |
| Adsorption of simple ions by nylon | 298 |
| Relation of acid uptake to amino group content | 298 |
| Adsorption in excess of amino groups | 302 |
| Titration with alkali. | 303 |
| Titration with other acids | 303 |
| Analysis of the adsorption isotherm of hydrochloric acid | 305 |
| Langmuir. | 305 |
| Donnan approach | 309 |
| Titration curves using dibasic ions | 312 |
| Adsorption of acid dyes | 318 |
| Importance of amine end groups | 319 |
| Overdyeing | 323 |

| | |
|--|-----|
| Measurement of affinity | 326 |
| Using free acids | 326 |
| Desorption | 330 |
| A generalised isotherm | 335 |
| Influence of dye structure | 338 |
| Dyeing in admixture | 340 |
| References | 343 |
| <i>Chapter 11.</i> Kinetics of dyeing nylon with acid dyes | 347 |
| Rates of dyeing | 347 |
| Diffusion of simple ions | 348 |
| Measurement of concentration profiles | 349 |
| Determination of the form of concentration dependence | 355 |
| Adsorption behaviour | 355 |
| Ionic "interaction" | 358 |
| Evaluation of the equations | 360 |
| Overdyeing | 362 |
| Average diffusion coefficients | 363 |
| Dyeing in admixture | 366 |
| Application to finite dyebaths | 373 |
| References | 376 |
| <i>Chapter 12.</i> Adsorption of direct dyes by cellulose | 379 |
| Application | 379 |
| High-temperature dyeing of direct dyes | 381 |
| After treatments | 382 |
| Diazotisation and coupling | 382 |
| After treatment with metallic salts | 382 |
| Formaldehyde | 383 |
| Treatment with cationic agents | 383 |
| Mechanism of dyeing | 384 |
| Adsorption by different substrates | 389 |
| Choice of volume term | 394 |
| Examination of a wide range of dyes | 396 |
| Calculation of dye on fibre from the affinity | 397 |
| Saturation values | 400 |
| Langmuir adsorption | 402 |
| Assessment of the equations | 412 |
| Effects of temperature on adsorption | 415 |
| Effects of salts | 419 |
| Dyeing in the absence of electrolyte | 419 |
| Sensitivity to salt | 419 |

| | |
|---|-----|
| Effects of different electrolytes | 423 |
| pH of the dyebath | 425 |
| Zeta potentials | 427 |
| Donnan distributions | 429 |
| Donnan potentials | 430 |
| Activity coefficients in solution | 439 |
| Dyeing with mixtures of dyes | 440 |
| References | 445 |
| | |
| Chapter 13. Kinetics of dyeing of cellulosic fibres | 449 |
| Analysis of concentration profiles | 452 |
| Diffusion of Benzopurpurine 4B | 457 |
| Steady-state data | 458 |
| Effect of temperature | 461 |
| Mechanism of diffusion | 461 |
| Adsorption model | 461 |
| Electrical potential model | 465 |
| Dyeing with mixtures of dyes | 467 |
| References | 470 |
| | |
| Chapter 14. Vat dyes | 473 |
| Indigoid dyes | 474 |
| Anthraquinone types | 475 |
| Reduction | 475 |
| The reduction process | 477 |
| Potentiometric measurements | 477 |
| Reducing agents | 485 |
| Control of vat dyebaths | 486 |
| Vat-o-meter, 486 – Titration, 487 – Electrometric methods, 487 | |
| Rates of reduction | 488 |
| Over-reduction | 493 |
| Dyeing. | 494 |
| Loose stock or yarn | 494 |
| Open width | 496 |
| (1) Jig dyeing, 496 – (2) Pad–develop processes, 496 – (3) Continuous processes, 497 | |
| Printing | 498 |
| Oxidation | 503 |
| Soaping of vat dyes | 504 |
| Adsorption of leuco dyes by cellulose | 510 |
| Solubilised vat dyes | 516 |
| Kinetics of dyeing | 518 |
| References | 520 |

| | |
|---|-----|
| Chapter 15. Azoic dyes | 523 |
| Stabilised diazonium compounds | 524 |
| The coupling reaction | 526 |
| Dyeing. | 528 |
| Printing | 529 |
| Soaping | 530 |
| Other fibres | 530 |
| Substantivity of naphthols | 532 |
| Kinetics of adsorption | 534 |
| References | 535 |
| Chapter 16. Dyeing of cellulose with Aniline Black and sulphur dyes. | 537 |
| Aniline Black | 537 |
| Application | 538 |
| Sulphur dyes | 539 |
| Application | 540 |
| Sulphurised vat dyes | 541 |
| Sulphurised anthracene or anthraquinone derivatives | 542 |
| Water-soluble dyes | 542 |
| References | 545 |
| Chapter 17. Dyeing with basic dyes | 547 |
| Basic dyes | 547 |
| Dyeing of cotton and wool | 548 |
| Acrylic fibres | 549 |
| Dyeing properties | 550 |
| Equilibrium behaviour | 553 |
| Action of sodium ions | 557 |
| More detailed analysis of the adsorption isotherm | 558 |
| The importance of sulphonate acid groups. | 563 |
| Kinetics of dyeing | 563 |
| Mechanism | 566 |
| Temperature effects. | 571 |
| Dyeing in admixture | 572 |
| Equilibrium data | 572 |
| Kinetics | 573 |
| Compatibility of basic dyes for acrylic fibres | 574 |
| Dyeing of modacrylic fibres. | 578 |
| References | 579 |

| | |
|---|-----|
| Chapter 18. Reactive dyes | 581 |
| Dyes for cellulose | 582 |
| Reactive dyes which form esters | 583 |
| Reactions of cyanuric chloride. | 585 |
| Triazinyl dyes | 586 |
| Hydrolysis of triazine dyes | 587 |
| Reactions with alcohols | 593 |
| Reaction with cellulose | 597 |
| Determination of the reaction constants with cellulose | 598 |
| Determination of CellO^- | 600 |
| Measurement of affinity and diffusion coefficients | 602 |
| Efficiency of fixation | 607 |
| Dyeing of cellulose with reactive dyes | 612 |
| Batchwise processes | 612 |
| Pad--develop techniques | 613 |
| Continuous methods | 616 |
| High fixation dyes | 616 |
| Dyes based on diazines | 617 |
| Pyrimidine derivatives | 617 |
| Dyes based on chloropyrimidines. | 619 |
| Other diazines | 622 |
| Reactive systems forming ether-type linkage | 624 |
| Dyes containing the precursor of the vinyl sulphone group | 624 |
| Other systems which form ethers. | 628 |
| Stability of dye—fibre bonds | 629 |
| Triazines | 629 |
| Diazinyl dyes | 630 |
| Reactive dyes for wool. | 632 |
| Triazine dyes | 632 |
| Vinyl sulphone dyes. | 638 |
| Acryloylamino dyes | 640 |
| Dye—fibre bond stabilities | 642 |
| Reactive dyes for nylon | 642 |
| Polyfunctional fixing agents. | 645 |
| References | 646 |
| Chapter 19. Metal-containing dyes | 649 |
| Direct dyes | 651 |
| Chrome dyes | 652 |
| Acid mordant or chrome dyes for wool | 652 |
| The chrome mordant process | 653 |
| The after-chrome process. | 653 |

| | | |
|--|-----|-----|
| The metachrome process | 654 | |
| Mechanism of "chroming" | 655 | |
| Premetallised dyes | 657 | |
| 1:1 Complexes | 660 | |
| 1:2 Complexes | 662 | |
| Affinity of 1:2 complexes | 665 | |
| The dyeing of nylon with chrome dyes | 666 | |
| Dyeing with 1:1 metal complexes | 667 | |
| Dyeing with 1:2 metal complexes | 667 | |
| References | 669 | |
| Chapter 20. Miscellaneous fibres | | 671 |
| Polypropylene fibres | 671 | |
| Adsorption isotherms | 672 | |
| Modified polypropylene | 673 | |
| Additives, 673 | | |
| "Nomex" | 675 | |
| Polyesters | 676 | |
| Acrylic fibres | 677 | |
| Nylon | 677 | |
| References | 679 | |
| Chapter 21. The relation between fibre structure and dyeing . | | 681 |
| General | 681 | |
| Dichroism | 686 | |
| ✓ Factors affecting dye uptake | 693 | |
| Mechanical treatments | 693 | |
| Heat treatments | 700 | |
| Nylon | 701 | |
| Polyesters | 708 | |
| Other fibres | 709 | |
| Relations with mechanical properties | 712 | |
| The importance of the glass transition temperature. T_g | 713 | |
| Relation with loss modulus | 717 | |
| Summary of the situation | 719 | |
| References | 720 | |
| Chapter 22. Carrier dyeing | | 723 |
| Introduction | 723 | |
| Rate increases on carrier addition | 724 | |
| Mechanism of carrier action | 726 | |
| Equilibrium isotherms | 729 | |

| | |
|---|-----|
| Kinetics | 730 |
| References | 739 |
| | |
| Chapter 23. The use of solvents in dyeing | 741 |
| Effects of solvent additions | 741 |
| Nylon dyeing | 744 |
| Dyeing of acrylic fibres | 744 |
| Coacervates | 744 |
| Dyeing from solvents | 744 |
| Adsorption of dyes | 746 |
| Equilibrium isotherms with disperse dyes, 746 — Rate of dyeing, 749 — Practical dyeing, 750 — Booster solvents, 750 | |
| Ionic dyes | 751 |
| References | 752 |
| | |
| Chapter 24. Diffusion models | 755 |
| Pore model | 755 |
| Diffusion processes | 759 |
| Free volume theory | 760 |
| References | 769 |
| | |
| Chapter 25. Mass transfer in dyeing systems | 771 |
| Importance of liquid layers | 773 |
| Convective diffusion | 776 |
| Dyeing of films of methoxymethyl nylon | 778 |
| Changing dyebath conditions | 782 |
| Model for diffusion in which film and liquid control are operative | 784 |
| Boundary layers for cylinders | 788 |
| Dyeing of fibre assemblies | 791 |
| Flow of liquids through packages | 794 |
| Permeability of packages | 798 |
| Practical considerations | 800 |
| Level dyeing of packages | 802 |
| Hank dyeing machines (Hussong) | 806 |
| Jig dyeing | 808 |
| Padding | 814 |
| Other factors affecting pick-up | 815 |
| Padding mechanisms | 817 |
| References | 819 |

| | |
|---|-----|
| Chapter 26. Relation between chemical constitution and substantivity | 823 |
| Cellulose dyes | 824 |
| Disperse dyes | 837 |
| Non-cellulosic fibres dyed with water-soluble dyes | 845 |
| The role of water. | 846 |
| References | 848 |
| • | |
| Chapter 27. Aggregation of dyes in solution | 851 |
| Reasons for aggregation | 852 |
| Methods for the study of solutions | 854 |
| Colligative and electrical methods | 854 |
| Diffusion methods | 856 |
| Microdiffusion, 858 — Porous plate method, 859 — Results of diffusion measurements, 860 | |
| Polarographic methods | 863 |
| Ultrafiltration | 866 |
| Light scattering | 867 |
| Calorimetry | 869 |
| Spectral changes | 870 |
| Potentiometric titrations | 872 |
| Summary of the position | 873 |
| Complexes with levelling agents | 874 |
| References | 878 |
| Index | 881 |