

9 REFERÊNCIAS

Ada, K., Ergene, A., Tan, S., 2008. **Materials Adsorption of Remazol Brilliant Blue R using ZnO fine powder: Equilibrium, kinetic and thermodynamic modeling studies.** Journal of Hazardous Materials, xxxx.

Allen, B., Strong, P., Price, C., Hubbard, S., Daston, G., 1996. **Benchmark dose analysis of developmental toxicity in rats Exposed to boric acid.** Fundamental and applied toxicology 32, 194–204.

Aks., Z., 2002. **Determination of the equilibrium, kinetic and thermodynamic parameters of the batch biosorption of nickel (II) ions onto Chlorellavulgaris.** Process Biochemistry, 38, 89-99.

Ayyildiz, H., Kara, A., 2005. **Boron removal by ion exchange mebranes.** Desalinitation 180, 99-108.

Azizian, S., 2004. **Kinetic models of sorption: a theoretical analysis.** Journal of Colloid and Interface Science 276, 47–52

Baldisarelli, Vanessa ., 2006. **estudo da adsorção do corante reativo preto 5 sobre carvão ativado: Caracterização do adsorvente e determinação de parâmetros cinéticos e termodinâmicos.** Dissertação de Mestrado em Química Universidade Regional de Blumenau

Bringmann, G., Kühn, R., 1980. **Comparison of the toxicity thresholds of water pollutants to bacteria, algae, and protozoa in the cell multiplication inhibition test.** Water research 14, 231-241.

Botelho, G., 1991. **Determinação de boro por espectrofotometria de absorção atômica no forno de grafite.** Tese de mestrado, Departamento de química, PUC-Rio, Brasil.

Bertocci., Mazzinghi., 1992. **Method for producing pure boric acid.** US patent 5,084,260

Black, J., Barnum, J., Birge, W., 1993. **An integrated assessment of the biological effects of boron to the rainbow trout.** [Chemosphere](#) 26, 1383-1413

Blevins, D. J., and Lukaszewski, K. M., 1994. **Proposed physiologic functions of boron in plants pertinent to animal and human metabolism.** Environmental Health Perspectives 102, Suppl. 7, 31–33.

Bick, A., Oron, G., 2005. **Post-treatment desing of sea water reverse osmosis plants: boron removal technology selection for potable water production and environmental control.** Desalination 178, 233-246.

Bruch, L., Cole, M., Zaremba E., 1997, **Physical adsorption : forces and phenomena,** International series of monographs on chemistry, 33.

Busch, M., Mickols, W., Jons, S., Redondo, J., Witte, J., 2006. **Boron Removal in Sea Water Desalination,** International Desalination Association BAH03-039 1

Butterwick, N., Raymond K., 1989. **Safety assessment of boron in aquatic and terrestrial environments.** *Ecotoxicol. Environ. Safe.* 17, 339–371

Cengeloglu Y., 2007 **Removal of boron from aqueous solution by using neutralized red mud** Journal of Hazardous Materials 142, 412–417

[Cheremisinoff](#), P., 2002. **Water And Water Pollution Handbook.** 2nd edition, New York, Wiley.

Choi, W., Chen, K., 1979. **Evaluation of boron removal by adsorption on solids.** American chemical society 13, 189-196.

[Choi, Y.](#), [McNeill, A.](#), [Coventry, D.](#), Stangoulis, J., 2006. **Whole plant response of crop and weed species to high subsoil boron** Australian Journal of Agricultural Research 7, 761-770.

Clairegerente, z., Andpierrelecloirec , y., 2002. **Adsorption of Several Metal Ions onto a Low-Cost Biosorbent: Kinetic and Equilibrium Studies** Environ. Sci. Technol. 36, 2067-2073

Dembitsky, V., Smoum, R., Al-Quntar, A., Srebnik, M., 2002. **Natural occurrence of boron-containing compounds in plants, algae and microorganisms.** Plant Science 163, 931-942.

Dilek, C., Özbelge, M., Biçak, N., Yılmaz, L., 2002. **Removal of boron from aqueous solutions by continuous polymer-enhanced ultrafiltration with polyvinyl alcohol.** [Separation Science and Technology](#) 37, 1257 – 1271.

Droguett, S., 1983. **Elementos de Catalisis Heterogenea, Serie de Química.** Secretaria General de la Organización de los Estados Americanos, Monografía No 26.

Dydo, P., Turek, M., Ciba, J., Trojanowska, J., Kluczka, J., 2005. **Boron removal from landfill leachate by means of nanofiltration and reverse osmosis.** Desalination 185, 131–137.

Dyer, S. D, 2001. **Determination of the aquatic PNEC_{0.05} for boron.** Chemosphere. (44) 369-376.

Eckenfelder, W. Jr., 1989 **Industrial water pollution control - 2nd. ed. -** New York : McGraw-Hill,

EPA 832-F-00-018, 2000. **Wastewater technology fact sheet chemical precipitation.** United States Environmental Protection Agency, Office of Water Washington, D.C.

Febrianto, J., Kosasih, A., 2009. **Equilibrium and kinetic studies in adsorption of heavy metals using biosorbent: A summary of recent studies** Journal of Hazardous Materials 162, 616–645

Ferreira, O., De Morães, S., Duran, N., Cornejo, L., Alves, O., 2006. **Evaluation of boron removal from water by hidrotalcite-like compounds.** Chemosphere, 62, 80-88.

Goldberg, S., 1997. **Reactions of boron with soils.** Plant and Soil 193, 35–48.

[Grieve, M., Poss, J.](#), 2000. **Wheat response to interactive effects of boron and salinity.** Journal of Plant Nutrition 23, 1217-1226.

Garcia-Soto, M., Camacho, E., 2005. **Boron removal from industrial wastewaters by ion exchange: an analytical control parameter.** Desalination. 181, 207-216.

Garcia – Soto, M., Camacho, E., 2005. **Boron Removal by Processes of Chemosorption** , Solvent Extraction and Ion Exchange, 23, 741–757.

Gulkova, D., Olcova, S., Zdravil., M., 2004. **Preparation of MgO catalytic support in shaped mesoporous high surface area form** Microporous and Mesoporous Materials 76, 137–149

Hameed, B. H., Salman, A.L., 2009. **Ahmad Adsorption isotherm and kinetic modeling of 2,4-D pesticide on activated carbon derived from date Ston** of Hazardous Materials 163, 121–126

Hermanek, S., 1992. **Boron chemistry: Introduccion.** American chemical society 92, 2.

Ho, Y. S. e McKAY, 1998 **A comparison of chemisorption kinetic models applied to pollutant removal on various sorbents** Institution of Chemical Engineers Trans IChemE, 76, B, November 1998, 32 – 340

Ho, Y. S. e McKAY , 1999. **A kinetic study of dye sorption by biosorbent waste product pith** Resources, Conservation and Recycling 25, 171–193

Ho, Y., McKay, G., 2000. **Correlative biosorption equilibria model for a binary batch system**, Chemical Engineering Science 55, 817-825.

HO, Y. S., 2004. **Citation review of Lagergren kinetic rate equation on adsorption reactions.** Scientometrics, 59, 171.177

Horta, A., 1977. **Determinação rápida de boro em água do mar por espectrofotometria de absorção atômica.** Tese de mestrado, DCMM, PUC-Rio, Brasil.

Hoffman, D., Camardese, M., Lecaptain, L., Pendleton, G., 1990. **Effects of boron on growth and physiology in mallard ducklings.** Environmental Toxicology and Chemistry 9, 335-346

Howe, P., 1998. **A review of boron effects in the environment.** Biological trace element research, 66, 153-165.

Inukai, Y., Tanaka, Y., Matsuda, T., Mihara, N., Yamada, K., Nambu, N., Itoh, O., Doi, T., Kaida, Y., Yasuda, S., 2004. **Removal of boron (III) by N-methylglucamine-type cellulose derivates with higher adsorption rate.** Analytica chimica acta 511, 261-265.

Itakura, T., Sasai, R., Itoh, H., 2005. **Precipitation recovery of boron from wastewater of boron from wastewater by hydrothermal mineralization.** Water Research 39, 2543-2548.

Juang., R., et al, 1997. **Adsorption Behavior of Reactive Dyes from Aqueous Solutions on Chitosan,** Journal of Chemical Technology and Biotechnology, 70, 391-399.

Kaftan, O., Acikel, M., Eroglu, A., Shahwan, T., Arkot, L., Ni, C., 2005. **Synthesis, Characterization and application of a novel sorbent, glucamine-modified MCM-41, for the removal/preconcentration of boron from waters.** Analytica chimica acta 547, 31-41.

Kramer, A. D. **Magnesium, its Alloys and Compounds** U.S. Geological Survey Open-File Report 01-341

Letterman, .D., 1999. **Water quality and treatment: a handbook of community water supplies,** 5 Ed. New York: McGraw-Hill: American Water Works Association.

Lide, D., 1998. **Handbook of chemistry and physic.** USA

Masel, R., 1951. **Principles of Adsorption and Reaction on Solid Surfaces** 2th ed, New York : Wiley

Markus Busch, Redondo, J., 2005. **Boron Removal in Sea Water Desalination**, *International Desalination Association BAH03-039* 1

Murray, F., 1995. **A human health risk assessment of boron (boric acid and borax) in drinking water**. *Regulatory toxicology and pharmacology* 22, 221-230.

Naday, N., 1999. **Boron removal from seawater reverse osmosis permeate utilizing selective ion exchange resin**. *Desalination* 124, 131-135.

Matsumoto, M., Kondo, K., Hirata, M., Kokubu, S., Hano, T., Takada, T., 1997. **Recovery of boric acid from wastewater by solvent extraction** *Separation science and technology* 32, 983-991

Metcalf & Eddie, 2003 **Wastewater engineering : treatment, disposal, and reuse** Inc. Boston : 4th ed. McGraw-Hill, Inc

Mesmer, E., Baes Jr., Sweeton, F., 1972. **Acidity Measurements at Elevated Temperatures. VI. Boric Acid Equilibria**, *Inorganic Chemistry*. 11, 3.

Mürüvvet, Y., Yoldaş, S., Senem, K., 2005. **Kinetic and thermodynamic studies of boron removal by Siral 5, Siral 40, and Siral 80**. *Journal of Colloid and Interface Science* 286, 440–446

Ministerio do Meio Ambiente, Conselho nacional do meio ambiente (Conama). **Resolução No 357/2005**.

Myers, D. **Surfaces, Interfaces, Colloids. Principles and Applications**. Weinheim, Germany, p. 39-67, 1991.

Nable, O., 1988. **Resistance to boron toxicity amongst several barley and wheat cultivars: a preliminary examination of the resistance mechanism**, *Plant and Soil*, The Hague, 112, 45-57.

Nadav, N., 1999. **Boron removal from seawater reverse osmosis permeate utilizing selective ion exchange resin**, Desalination 124, 131-135.

NPI, National Pollutant Inventory., 2006. **Boron & compounds fact sheet**. Australian government, Department of the environmental and heritage. <http://www.npi.gov.au/index.html>

Okay, O., Guclu, H., Soner E., Balkas, T., 1985. **Boron pollution in the Simav river, Turkey and various methods of boron removal**. Water research 19, 857-862.

Oren, Y., Linder, C., Daltrophe, N., Mirsky, Y., Skorka, J., Kedem, O., 2006. **Boron removal from desalinated seawater and brackish water by improved electro dialysis**. Desalination 199, 52–54

Oscik, J. **Adsorption**, Ellis Horwood, Chichester, 32, 1982.

Owen, B., 1934. **The dissociation constant of boric acid from 10 and 50°**. J. Am. Chem. Soc. 56, 1965-1697.

Özcan, S., Özcan A., 2004. **Adsorption of Acid Dyes from Aqueous Solutions Onto Acid-Activated Bentonite**, Journal of Colloid and Interface Science, 276, 39-46.

Öztürk , N., Kavak, D., 2008. **Boron removal from aqueous solutions by batch adsorption onto cerium oxide using full factorial design**, Desalination, 223, 106–112.

Pollock., Charles, W., 1976. **Recovery of boric acid from ion exchangers**. US Patent 3,983,220.

Perche, F., 2004. **adsorption de polycarboxylates et de lignosulfonates sur poudre modèle et ciments** thèse no 3041 école polytechnique fédérale de lausanne université de rouen, france et de nationalité française acceptée

Pino Gabriela., 2005 **Biossorção de Metais Pesados Utilizando Pó da Casca de Coco Verde (Cocos nucifera)** Dissertação de Mestrado Departamento de Ciência dos Materiais e Metalurgia da PUC-Rio.

Power, P., Woods, W., 1997. **The chemistry of boron and its speciation in plants** Plant and Soil 193, 1–13.

Price, C., Marr, M., Myers, C., Seely, J., Heindel, J., Schwetz, B., 1996. **The developmental toxicity of boric acid in rabbits.** Fundamental and applied toxicology 34, 176–187.

Prats, D., Chillon-Arias, F., Rodriguez-Pastor, F., 2000. **Analysis of the influence of pH and pressure on the elimination of boron in reverse osmosis** Desalination 128, 269-273.

Pastor, M., Ruiz, F., 2001. **Influence of pH in the elimination of boron by means of reverse osmosis.** Desalination 140, 145-152.

Polat, H., Vengosh, A., Pankratov, I., Polat, M., 2004. **A new methodology for removal of boron from water by coal and fly ash.** Desalination, 14, 173-188.

Parks, J., Edwards, M., 2005. **Boron in the environment.** Critical reviews in environmental science and technology, 35, 81-114.

Kabay, N., Yilmaz, N., Yamac, S., Samatyab, S., Yuksela, M., Yuksel, U., Ardab, M., Saglama, M., Iwanagac, T., Hirowatari K., 2004. **Removal and recovery of boron from geothermal wastewater by selective ion exchange resins. I. Laboratory tests.** Reactive & Functional Polymers 60, 163–170.

Kabay, N., Bryjak, M., Schollosser, S., Kitisa, M., 2008. **Adsorption-membrane filtration (AMF) hybrid process for boron removal from seawater: an overview,** Desalination 223, 38–48.

Kannan, N., Sundaram, M., 2001. **Kinetics and Mechanism of Removal of Methylene Blue by Adsorption on Various Carbons – a Comparative Study,** Dyes and Pigments, 51, 25-40.

Kavak, D., 2008. **Removal of boron from aqueous solutions by batch adsorption on calcined alunite using experimental design,** Journal of Hazardous Materials xxx–xxx.

Kratochvil, D., Volesky, B. **Advances in biosorption of heavy metals** in *Biotechnology*, 16, p. 291-300, 1998.

Remy, P., Muhr, H., Plasari, E., Ouerdiane, I., 2005. **Removal of boron from wastewater by precipitation of a sparingly soluble salt**. *Environmental progress* 24, 105-110.

Reynolds, T. D. e Richards, P. A. **Unit operations and processes in environmental engineering**, PWS publishing company, Boston, MA., 1992.

Ribeiro, M., Paim, T., Rocha, S., 2006. **Precipitation of Heavy Metals using Magnesium Based Compounds**, AAIQ Asociación Argentina de Ingenieros Químicos IAACHE- Interamerican Cofederation of Chemical Engineering.

Rohm and Hass Quimica Ltda. **Resinas de Troca Iônica** www.rohmhaas.com/around/LAR.html

Ruthven, D.M. **Principles of adsorption and adsorption processes**, Wiley, New York, 1984.

Russell, J. B. **General Chemistry**. McGraw-Hill, New York, 1980.

Seki, Y., Seyhan, S., Yurdakoc, M., 2006. **Removal of boron from aqueous solution by adsorption on Al₂O₃ based materials using full factorial desing**. *Journal of Hazardous materials*. Article in press.

Shono., Kanji., Kitoh., Tokio., Sano., Hiroshi., Hironaka., Takashi., 1982. **Method of recovering boric acid**. US patent, 4,329,154.

Simonnot, M., Castel, C., Nicolai, M., Rosin, C., Sardin, M., Jauffret, H., 2000. **Boron removal from drinking water with a boron selective resin: is the treatment really selective?**. *Water research* 34, 109-116.

Sivaraj, R., Namasivayam, C., 2001. **Orange peel as an adsorbent in the removal of Acid violet 17 (acid dye) from aqueous solutions**, *Waste Management* 21 105-110

Smallwood, C., Lipscomb, J., Swartout, J., 2001. **Toxicological review of boron and compounds: In support of summary information on the integrated risk information system (IRIS)**. U.S. Environmental Protection Agency EPA (CA- 7440-42-8)

Stanley, Jr., Thomas, R., Smith, J., Hoffman, J., Heinz, H., Rosscoe, R., 1996. **Effects of boron and selenium on mallard reproduction and duckling growth and survival**. *Environmental Toxicology and Chemistry* 15, 1124-1132.

Sun, Q., Yang, L., Lu, P., 2004. **The adsorption of lead and copper from aqueous solution on modified peat-resin particles**, *Environmental Geochemistry and Health* 26, 311–317.

Taniguchi, M., Fusaoka, y., Nishikawa, T., Kurihara, M., 2004. **Boron removal in RO seawater desalination**. *Desalination* 167, 419-426.

Vengosh, A., Heumann, K., Juraske, S., Kashers, R., 1994. **Boron Isotope Application for Tracing Sources of Contamination in Groundwater**. *Environ. Sci. Technol* 28, 1968-1974

Volesky, B., **Sorption and Biosorption**. 2003, BV Sorbex, Canada.

Weir, R., Fisher, R., 2001. **Influence of pH in the elimination of boron by means of reverse osmosis**. *Desalination* 140, 145-152

Wilt, M., Bartels C., 2005. **Optimization of seawater RO systems design** *Desalination* 173, 1-12

Winkler, J., 1907. **Factors in boric acid manufacture**. *J. Am. Chem. Soc.*, Vol 29 (9), 1366–1371

Wolf, P., Siverns, S., Monti, S., 2005. **UF membranes for RO desalination pretreatment**. *Desalination* 182, 293–300.

Xu, Y., and Jiang J., 2008. **Technologies for Boron Removal** *Ind. Eng. Chem. Res.*, 47 (1), 16-24

Xuea, Y., Houa, H., Zhua, S., 2009. **Adsorption removal of reactive dyes from aqueous solution by modified basic oxygen furnace slag: Isotherm and kinetic study.** Chemical Engineering Journal 147, 272–279

Yilmaz, A., Boncukcuoglu, R., Kocakerim, M., Keskinler, B., 2005. **The investigation of parameters affecting boron removal by electrocoagulation method .** Journal of Hazardous materials B125, 160-165.

Yoldas, S., Serap, S., Yurdakoc, M., 2006. **Removal of boron from aqueous solution by adsorption on Al₂O₃ based materials using full factorial design,** Journal of Hazardous Materials. xxx, xxx-xxx.

Yurdakoc, M., Seki, Y., Karahan, S., Yurdakoc, K., 2005. **Kinetic and thermodynamic studies of boron removal by siral 5, siral 40 and siral 80.** Journal of colloid and interface science 286, 440-446.

Wen, R., 1978.

Zhang, M., Reardon, E., 2003. **Removal of B, Cr, Mo and Se from wastewater by incorporation into hydrocalumite and ettringite.** Environ. Sci. Technol. 37, 2974-2952.

APENDICE

A1 - Caracterização do MgO-500 após o processo de adsorção

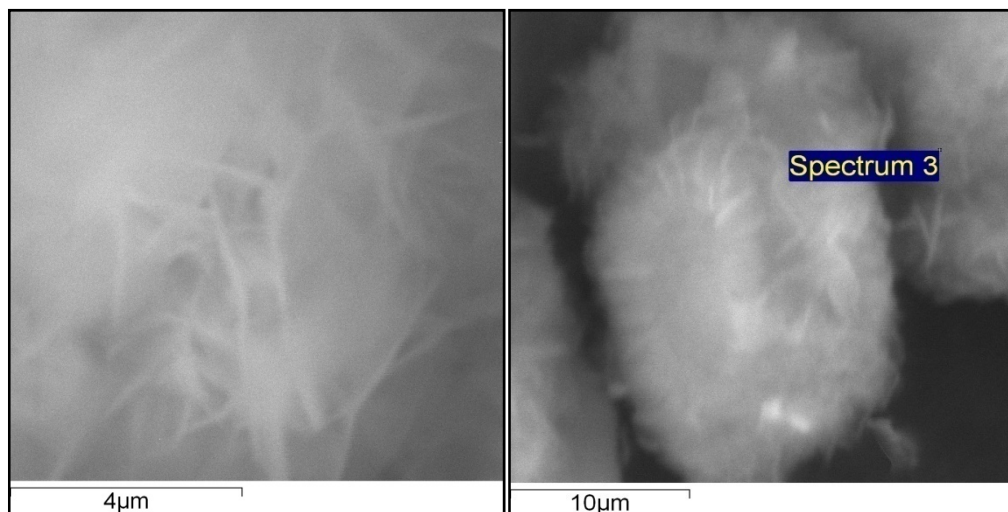


Figura A1 – Microfotografias do MgO após o processo de adsorção de boro, obtidas através do Microscópio Eletrônico de Varredura. Conc. inicial do boro: 350mg.L⁻¹, concentração do MgO: 40 g.L⁻¹, pH:10, temperatura: 25°C, agitação:150 rpm e tempo: 240 min.

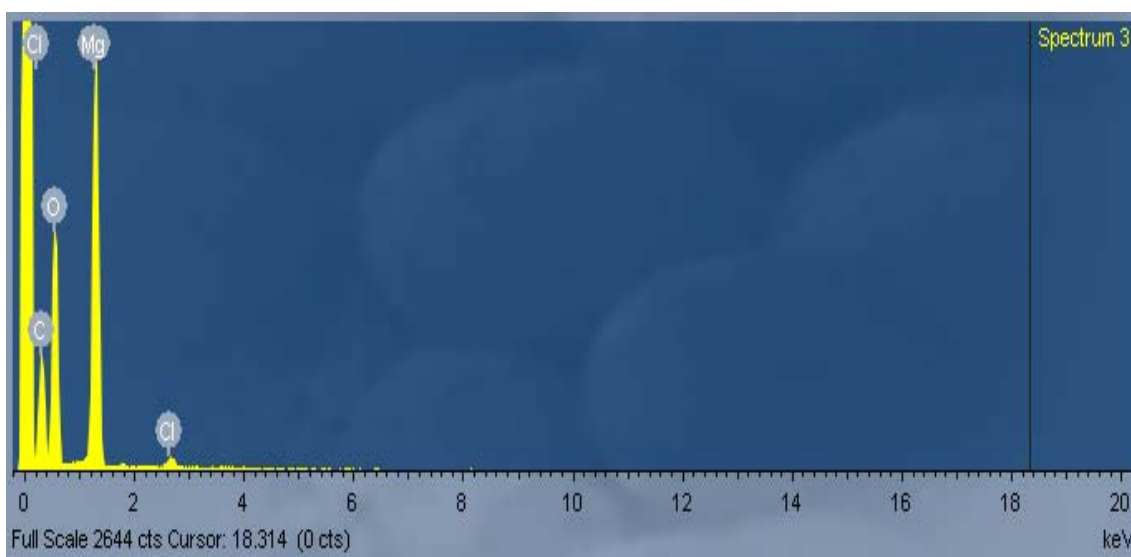


Figura A2 – Composição elemental do adsorvente após o contato com o boro na solução. Conc. inicial do boro: 350mg.L⁻¹, concentração do MgO: 40 g.L⁻¹, pH:10, temperatura: 25°C, agitação:150 rpm e tempo: 240 min

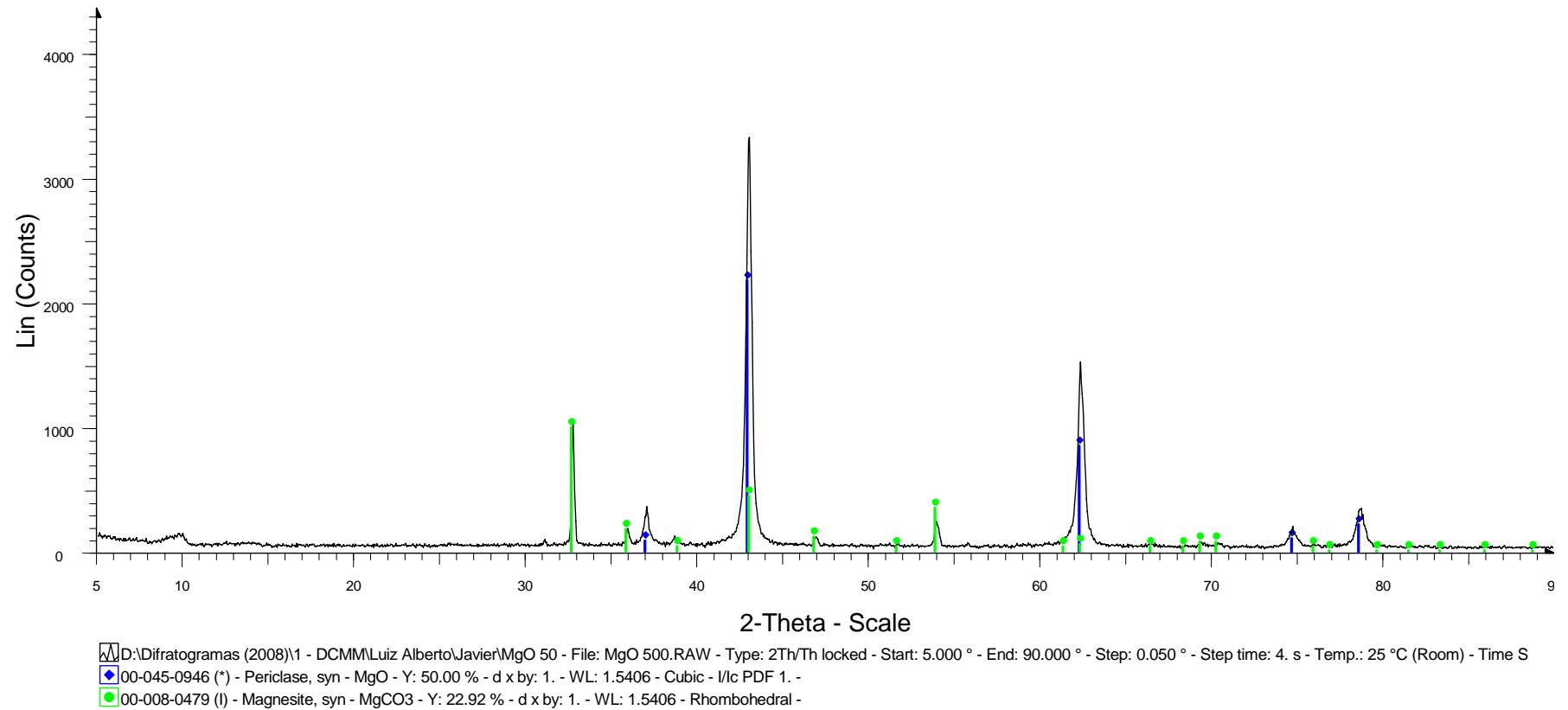
A2 - Difractogramas do MgO-200, MgO-325 e MgO-500

Figura A3 – Difractograma de raios-X da amostra MgO-200

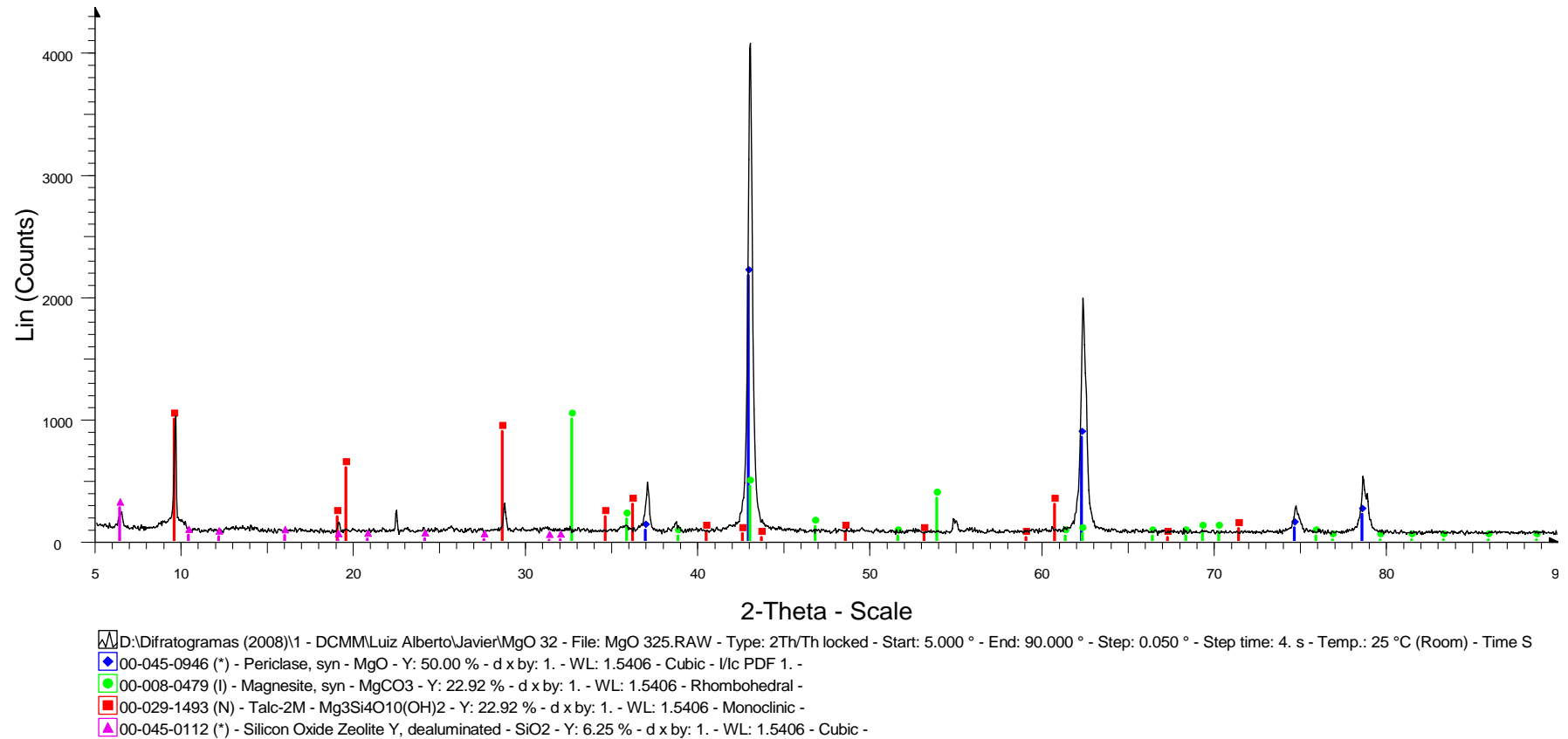


Figura A4 – Difratoograma de raios-X da amostra MgO-325.

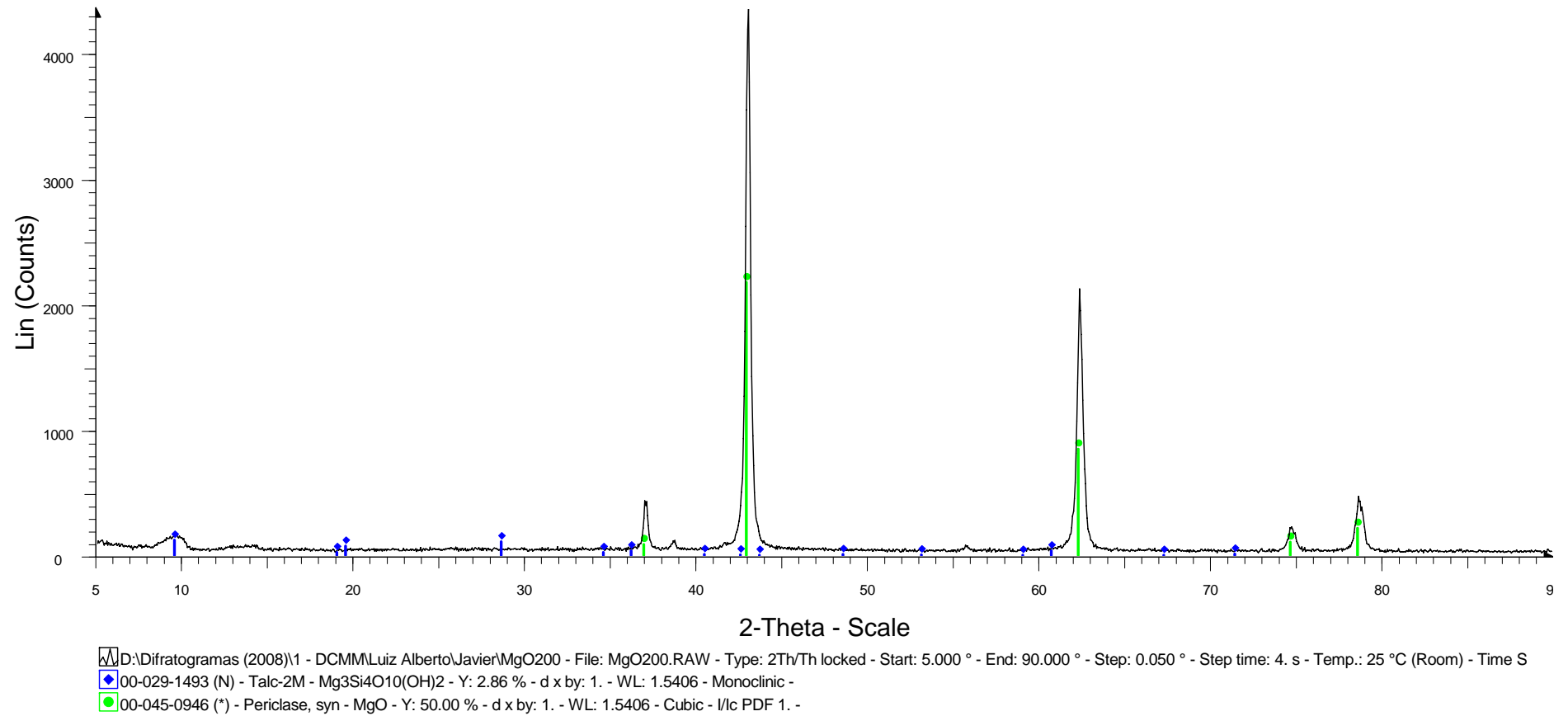


Figura A5 – Difratoograma de raios-X da amostra MgO-500.

A3 - Cálculos para o ajuste de dados aos modelos de isothermas de adsorção

Tabela A1- Calculo dos dados experimentais para o ajuste aos modelos de isothermas de Adsorção a 25°C.

m, g	Ce	Co	x (Co-Ce)	qe (x/m)	Ce/(x/m)	1/(x/m)	1/Ce	Ce/x	LogCe	Log(x/m)
0,00	350,00	350,00	0,00							
8,00	220,00	350,00	130,00	16,25	13,54	0,06	0,00	1,69	2,34	1,21
16,00	150,00	350,00	200,00	12,50	12,00	0,08	0,01	0,75	2,18	1,10
24,00	112,00	350,00	238,00	9,92	11,29	0,10	0,01	0,47	2,05	1,00
32,00	87,00	350,00	263,00	8,22	10,59	0,12	0,01	0,33	1,94	0,91
40,00	75,00	350,00	275,00	6,88	10,91	0,15	0,01	0,27	1,88	0,84
48,00	54,44	350,00	295,56	6,16	8,84	0,16	0,02	0,18	1,74	0,79
56,00	47,00	350,00	303,00	5,41	8,69	0,18	0,02	0,16	1,67	0,73
64,00	40,00	350,00	310,00	4,84	8,26	0,21	0,03	0,13	1,60	0,69

Tabela A2- Calculo dos dados experimentais para o ajuste aos modelos de isothermas de Adsorção a 40°C.

m, g	Ce	Co	x (Co-Ce)	qe (x/m)	Ce/(x/m)	1/(x/m)	1/Ce	Ce/x	LogCe	Log(x/m)
0,00	350,00	350,00	0,00							
8,00	200,00	350,00	150,00	18,75	10,67	0,05	0,01	1,33	2,30	1,27
16,00	130,00	350,00	220,00	13,75	9,45	0,07	0,01	0,59	2,11	1,14
24,00	95,00	350,00	255,00	10,63	8,94	0,09	0,01	0,37	1,98	1,03
32,00	70,00	350,00	280,00	8,75	8,00	0,11	0,01	0,25	1,85	0,94
40,00	53,00	350,00	297,00	7,43	7,14	0,13	0,02	0,18	1,72	0,87
48,00	40,00	350,00	310,00	6,46	6,19	0,15	0,03	0,13	1,60	0,81
56,00	35,00	350,00	315,00	5,63	6,22	0,18	0,03	0,11	1,54	0,75
64,00	30,00	350,00	320,00	5,00	6,00	0,20	0,03	0,09	1,48	0,70

Tabela A3 - Cálculo dos dados experimentais para o ajuste aos modelos de isotermas de Adsorção a 50°C.

m, g	Ce	Co	x (Co-Ce)	qe (x/m)	Ce/(x/m)	1/(x/m)	1/Ce	Ce/x	LogCe	Log(x/m)
0,00	350,00	350,00	0,00							
8,00	193,00	350,00	157,00	19,63	9,83	0,05	0,01	1,23	2,29	1,29
16,00	123,00	350,00	227,00	14,19	8,67	0,07	0,01	0,54	2,09	1,15
24,00	88,00	350,00	262,00	10,92	8,06	0,09	0,01	0,34	1,94	1,04
32,00	63,00	350,00	287,00	8,97	7,02	0,11	0,02	0,22	1,80	0,95
40,00	49,00	350,00	301,00	7,53	6,51	0,13	0,02	0,16	1,69	0,88
48,00	36,00	350,00	314,00	6,54	5,50	0,15	0,03	0,11	1,56	0,82
56,00	31,00	350,00	319,00	5,70	5,44	0,18	0,03	0,10	1,49	0,76
64,00	28,00	350,00	322,00	5,03	5,57	0,20	0,04	0,09	1,45	0,70

A4 - Cálculos para o ajuste de dados aos modelos cinéticos do processo de adsorção

Tabela A4 – Cálculos dos dados experimentais para o ajuste de dados aos modelos cinéticos do processo de adsorção a 25°C.

Tempo (min)	C (mg/L)	Co (mg/L)	M (g)	X (mg/)	q (mg/g)	% remoção	ln(qe - q)	q (mg/g)	t/q
0,00	350,00	350,00	40,00	0,00	0,00	0,00		0,00	
5	150	350,00	40,00	200,00	5,00	57,14	0,98	5,00	1,00
10	125	350,00	40,00	225,00	5,63	64,29	0,72	5,63	1,78
15	102	350,00	40,00	248,00	6,20	70,86	0,39	6,20	2,42
20	95	350,00	40,00	255,00	6,38	72,86	0,26	6,38	3,14
30	75	350,00	40,00	275,00	6,88	78,57	-0,22	6,88	4,36
40	61	350,00	40,00	289,00	7,23	82,57	-0,80	7,23	5,54
60	56	350,00	40,00	294,00	7,35	84,00	-1,12	7,35	8,16
90	51	350,00	40,00	298,76	7,47	85,36	-1,58	7,47	12,05
140	46	350,00	40,00	304,00	7,60	86,86	-2,59	7,60	18,42
190	44	350,00	40,00	306,00	7,65	87,43	-3,69	7,65	24,84
240	43	350,00	40,00	307,00	7,68	87,71	-	7,68	31,27

Tabela A5 - Cálculos dos dados experimentais para o ajuste de dados aos modelos cinéticos do processo de adsorção a 40°C.

Tempo (min)	C (mg/L)	Co (mg/L)	M (g)	X (mg/)	q (mg/g)	% remoção	ln(qe -q)	q (mg/g)	t/q
0,00	350,00	350,00	40,00	0,00	0,00	0,00		0,00	
5	130,00	350,00	40,00	220,00	5,50	62,86	0,94	5,50	0,91
10	85,00	350,00	40,00	265,00	6,63	75,71	0,35	6,63	1,51
15	61,00	350,00	40,00	289,00	7,23	82,57	-0,19	7,23	2,08
20	54,00	350,00	40,00	296,00	7,40	84,57	-0,43	7,40	2,70
30	40,00	350,00	40,00	310,00	7,75	88,57	-1,20	7,75	3,87
40	37,00	350,00	40,00	313,00	7,83	89,43	-1,49	7,83	5,11
60	33,00	350,00	40,00	317,00	7,93	90,57	-2,08	7,93	7,57
90	31,00	350,00	40,00	319,00	7,98	91,14	-2,59	7,98	11,29
140	29,50	350,00	40,00	320,50	8,01	91,57	-3,28	8,01	17,47
190	28,70	350,00	40,00	321,30	8,03	91,80	-4,05	8,03	23,65
240	28,00	350,00	40,00	322,00	8,05	92,00	-	8,05	29,81

Tabela A5 - Cálculos dos dados experimentais para o ajuste de dados aos modelos cinéticos do processo de adsorção a 50°C

Tempo (min)	C (mg/L)	Co (mg/L)	M (g)	X (mg/)	q (mg/g)	% remoção	ln(qe -q)	q (mg/g)	t/q
0,00	350	350,00	40,00	0,00	0,00	0,00		0,00	
5	126	350,00	40,00	224,00	5,60	64,00	0,94	5,60	0,89
10	63	350,00	40,00	287,00	7,18	82,00	-0,03	7,18	1,39
15	31	350,00	40,00	319,00	7,98	91,14	-1,74	7,98	1,88
20	29	350,00	40,00	321,00	8,03	91,71	-2,08	8,03	2,49
30	28,6	350,00	40,00	321,40	8,04	91,83	-2,16	8,04	3,73
40	27,5	350,00	40,00	322,50	8,06	92,14	-2,44	8,06	4,96
60	26,5	350,00	40,00	323,50	8,09	92,43	-2,77	8,09	7,42
90	25,9	350,00	40,00	324,10	8,10	92,60	-3,05	8,10	11,11
140	25	350,00	40,00	325,00	8,13	92,86	-3,69	8,13	17,23
190	24,4	350,00	40,00	325,60	8,14	93,03	-4,61	8,14	23,34
240	24	350,00	40,00	326,00	8,15	93,14	-	8,15	29,45