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**AGU PUBLICATIONS**  
**Journal of Geophysical Research: Biogeosciences**  
 RESEARCH ARTICLE  
 10.1002/2016JG003464

**Fluvial carbon export from a lowland Amazonian rainforest in relation to atmospheric fluxes**

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**Abstract** We constructed a whole carbon budget for a catchment in the Western Amazon Basin, combining drainage water analyses with eddy covariance (EC) measured terrestrial CO<sub>2</sub> fluxes. As fluvial C export can represent permanent C export it must be included in assessments of whole site C balance, but it is rarely done. The footprint area of the flux tower is drained by two small streams (~5–7 km<sup>2</sup>) from which we measured the dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), particulate organic carbon (POC) export, and CO<sub>2</sub> efflux. The EC measurements showed the site C balance to be +0.7 ± 9.7 Mg C ha<sup>-1</sup> yr<sup>-1</sup> (a source to the atmosphere) and fluvial export was 0.3 ± 0.04 Mg C ha<sup>-1</sup> yr<sup>-1</sup>. Of the total fluvial loss 34% was DIC, 37% DOC, and 29% POC. The wet season was most important for fluvial C export. There was a large uncertainty associated with the EC results and with previous biomass plot studies (−0.5 ± 4.1 Mg C ha<sup>-1</sup> yr<sup>-1</sup>); hence, it cannot be concluded with certainty whether the site is C sink or source. The fluvial export corresponds to only 2–7% of the uncertainty related to the site C balance; thus, other factors need to be considered to reduce the uncertainty and refine the estimated C balance. However, stream C export is significant, especially for almost neutral sites where fluvial loss may determine the direction of the site C balance. The fate of C downstream then dictates the overall climate impact of fluvial export.

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**Research**

**Scaling leaf respiration with nitrogen and phosphorus in tropical forests across two continents**

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**Abstract** Leaf dark respiration ( $R_{\text{dark}}$ ) represents an important component controlling the carbon balance in tropical forests. Here, we test how nitrogen (N) and phosphorus (P) affect  $R_{\text{dark}}$  and its relationship with photosynthesis using three widely separated tropical forests which differ in soil fertility.

**Keywords** leaf respiration, nitrogen (N), phosphorus (P), photosynthesis, tropical forest.

**Introduction**  
 Leaf dark respiration ( $R_{\text{dark}}$ ) represents a large fraction of total plant respiration (Atkin *et al.*, 2007) and, as such, can play an important role in determining the rates of whole-plant net carbon uptake. In tropical forests, leaf  $R_{\text{dark}}$  comprises a sufficient percentage of total plant respiration (Metcalfe *et al.*, 2010; Huntingford *et al.*, 2013; da Costa *et al.*, 2014; Rowland *et al.*, 2014a), such that variations in CO<sub>2</sub> emissions from  $R_{\text{dark}}$  could determine whether tropical forests act as a source or sink of atmospheric CO<sub>2</sub> (Meir *et al.*, 2008; Gatti *et al.*, 2014; Rowland *et al.*, 2014a). Consequently, insights into the key determinants of variation in leaf  $R_{\text{dark}}$  are needed to improve estimates of likely shifts in the source and sink capacity of tropical forests under different climate forcing scenarios. In addition to the role of genotype in influencing basal rates of leaf  $R_{\text{dark}}$  (Atkin *et al.*, 2015), variations in respiratory fluxes can occur in response to environmental gradients, such as temperature, water availability and nutrient supply (Reich *et al.*, 1998a; Meir *et al.*, 2001; Wright *et al.*, 2006; Atkin *et al.*, 2015), and with leaf nitrogen (N) and phosphorus (P) concentrations (Reich *et al.*, 1998a; Meir *et al.*, 2001; Turnbull *et al.*, 2005; Wright *et al.*, 2006; Atkin *et al.*, 2015). An effect of low nutrient concentration on both leaf  $R_{\text{dark}}$  and photosynthetic capacity has been observed in the tropics, particularly for P (Meir *et al.*, 2001, 2007; Katge *et al.*, 2009; Domingues *et al.*, 2010; Slot *et al.*, 2013, 2014), although the relationships can be complex (Domingues *et al.*, 2015) and relatively little is known about the biogeographical variation in leaf  $R_{\text{dark}}$  among tropical forests. In soil-vegetation-atmosphere modelling frameworks, rates of respiratory CO<sub>2</sub> release are often associated with leaf photosynthetic CO<sub>2</sub> uptake (A), and leaf physicochemical and/or structural

function without the complicating influence of variation in temperature seasonality and winter dormant seasons (Malhi *et al.*, 2010; Sundqvist *et al.*, 2013).

It is valuable to distinguish direct environmental controls on ecosystem productivity from indirect controls mediated through forest structure and composition, and to determine the degree to which productivity can be estimated from surveying ecosystem composition. Environmental conditions are usually considered direct drivers of ecosystem productivity (Fig. 1). Although in most tropical regions temperature is not a limiting factor on productivity, some studies suggest that across sites, tree growth increases with mean temperature (Reich *et al.*, 1997; Cleveland *et al.*, 2011) within the temperature range of currently observed tropical climates. In seasonal tropical forests, rainfall is positively associated with tree growth (Bremer & Zuidema 2005), while other studies identify solar radiation as a key driver of

function without the complicating influence of variation in temperature seasonality and winter dormant seasons (Malhi *et al.*, 2010; Sundqvist *et al.*, 2013).

It is valuable to distinguish direct environmental controls on ecosystem productivity from indirect controls mediated through forest structure and composition, and to determine the degree to which productivity can be estimated from surveying ecosystem composition. Environmental conditions are usually considered direct drivers of ecosystem productivity (Fig. 1). Although in most tropical regions temperature is not a limiting factor on productivity, some studies suggest that across sites, tree growth increases with mean temperature (Reich *et al.*, 1997; Cleveland *et al.*, 2011) within the temperature range of currently observed tropical climates. In seasonal tropical forests, rainfall is positively associated with tree growth (Bremer & Zuidema 2005), while other studies identify solar radiation as a key driver of

**Polymer-Plastics Technology and Engineering**

Development of biopolymer nanocomposites based on polysaccharides obtained from red algae *Chondracanthus Chamosoi*, reinforced with chitin whiskers and montmorillonite

Sol Angel Rodriguez, Erin Weese, Javier Nakamatsu & Fernando Torres

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**ECOLOGY LETTERS**  
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**LETTER** Solar radiation and functional traits explain the decline of forest primary productivity along a tropical elevation gradient

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 Yadvinder Malhi<sup>1</sup>

**Abstract** One of the major challenges in ecology is to understand how ecosystems respond to changes in environmental conditions and how taxonomic and functional diversity mediate these changes. In this study, we use a trait-spectra and individual-based model, to analyse variation in forest primary productivity along a 3.3 km elevation gradient in the Amazon-Andes. The model accurately predicted the magnitude and trends in forest productivity with elevation, with solar radiation and plant functional traits (leaf dry mass per area, leaf nitrogen and phosphorus concentration, and wood density) collectively accounting for productivity variation. Remarkably, explicit representation of temperature variation with elevation was not required to achieve accurate predictions of forest productivity, as trait variation driven by species turnover appears to capture the effect of temperature. Our semi-mechanistic model suggests that spatial variation in traits can potentially be used to estimate spatial variation in productivity at the landscape scale.

**Keywords** Andes, climate, functional traits, global ecosystem monitoring, modelling, TFS, tropical forests.

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**INTRODUCTION**  
 One of the major challenges in contemporary ecosystem science is to understand how ecosystems respond to changes in environmental conditions, and how taxonomic and functional diversity mediate these changes (Lavorel & Garnier 2002). Environmental conditions change both in time and in space, and transects along environmental gradients can provide valuable insights into controls of ecosystem function. Tropical forest environmental gradients present a particularly rich study system (Vazquez & Givnish 1998; Wright 2002), with their high diversity facilitating general insights into the relationships between diversity and function that are not contingent on the characteristics and the presence or absence of particular dominant species. More specifically, tropical elevation gradients, with their usually high levels of soil moisture

**Applied Polymer**  
 SCIENCE

**Laccase-mediated grafting of polyphenols onto cationized cotton fibers to impart UV protection and antioxidant activities**

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**Abstract** Enzyme-mediated *in situ* functionalization of cotton fibers was studied using laccase. Caffeic acid and morin were used as reactive phenolic substrates for laccase and further employed to the modification of fiber surfaces. Laccase-mediated oxidation and polymerization reactions of caffeic acid were monitored by ultraviolet-visible spectroscopy. During the wetting process, initial cationization of fiber surface using poly(diallyldimethylammonium chloride) followed by enzymatic treatment with phenolic substrates resulted ineffective polymer grafting evidenced by high color stability. Changes of fiber surface properties by polymer grafting, such as morphology and hydrophilicity/hydrophobicity, were tested using scanning electron microscopy and gravimetric absorption tests. An acceptable level of color resistance to washing stress was obtained on caffeic acid treated samples, and a high level of rubbing resistance was obtained on samples treated with both caffeic acid and morin. Regarding the ultraviolet protection test, the cationized and enzymatically functionalized samples showed a very good protection grade (ultraviolet protection factor = 25). Finally, the antioxidant activity test of the modified fibers presented an improvement for radical scavenging potential due to the phenolic compounds incorporated to cotton fibers by laccase-mediated catalysis. © 2017 Wiley Periodicals, Inc. *J. Appl. Polym. Sci.* 2017, 135, 45801

**Keywords** applications; catalysts; coatings; polyelectrolytes; textiles

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**INTRODUCTION**  
 Polyphenols are found in a variety of dietary plants and characterized with aromatic rings bearing more than one hydroxyl moieties.<sup>1,2</sup> The hydroxyl groups in polyphenol molecules have an essential role in providing antioxidant activity.<sup>3,4</sup> The most common dietary polyphenols are flavonoids and phenolic acids, they are the most important group of secondary metabolites and bioactive compounds in plants and act as protectors against oxidative oxygen and nitrogen species, ultraviolet (UV) light, pathogens, etc.<sup>5</sup> Flavonoids are found in the form of β-glycosides and their chemical nature and bioactivities depend on their molecular structure, degree of hydroxylation, substituents and conjugations, and their degree of polymerization.<sup>6</sup> They possess great potential as reducing agents, hydroge-

donating antioxidants, and singlet oxygen quenchers.<sup>7,8</sup> Phenolic acids are hydroxylated derivatives of benzoic and cinnamic acid; they have received great attention as bioactive agents for their antioxidants, antiapoptotic, and anti-inflammatory capacities.<sup>9,10</sup>

The potential applications of both flavonoids and phenolic acids are broadly studied in the biological, medical, and pharmaceutical areas,<sup>11,12</sup> and have also found interest for the modification of raw materials such as cotton and flax fibers to provide them new functionalities, that is, coloration and antioxidant and antimicrobial activities.<sup>13–15</sup> There are studies about modification and/or functionalization of fibers with polyphenols using oxidoreductases such as laccases and peroxidases. Both enzymes catalyze radical generating reactions by reduction and

\* Solo se incluyen artículos de miembros de la Sección Química de la PUCP que aparezcan firmados con la afiliación a esta sección, independientemente de si los colaboradores son, o no, de la PUCP desde el 1 de octubre de 2016 hasta el 15 de diciembre de 2017 (no se incluyen artículos aceptados en 2017 que aparezcan con fecha de 2018 en la revista). El acceso al artículo depende de la suscripción del usuario a las editoriales correspondientes. Se han incluido solo revistas científicas que se encuentran indexadas en las bases de datos Scopus y Web of Science, de reconocido prestigio internacional.

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Analytical Chemistry Research

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### Sensors based on Ag-loaded hematite ( $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>) nanoparticles for methyl mercaptan detection at room temperature

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**ABSTRACT**

Sensors based on Ag/α-Fe<sub>2</sub>O<sub>3</sub> nanoparticles have been prepared by the coprecipitation method. Sensing methyl mercaptan at room temperature. X-ray diffraction patterns of samples matched perfectly with characteristic peaks of hematite with no peaks assigned to Ag even at the highest concentration. STEM images and EDX analysis revealed the presence of Ag nanoparticles (from 2 to 5 nm) which we highly dispersed onto α-Fe<sub>2</sub>O<sub>3</sub> surface with an Ag/Fe ratio from 0.014 to 0.099. The Ag nanoparticles we deposited on the hematite surface. Sensing tests of Ag-loaded hematite nanoparticles showed high response signal than the unmodified sensor. Hematite loaded with 33(Wt) Ag showed the high response with a linear dependence from 20 to 80 ppm. The sensor also depicted a good selectivity a stability during 4 days with short recovery time. The high dispersion of reduced Ag evaluated by X analysis played an important chemical role in the sensing mechanism that favored the contact of CH<sub>3</sub>S with oxygen.  
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### Highly sensitive ratiometric quantification of cyanide in water with gold nanoparticles via Resonance Rayleigh Scattering

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**ABSTRACT**

A highly sensitive and selective ratiometric sensor for the quantification of cyanide (CN<sup>-</sup>) in aqueous solution has been developed using spherical gold nanoparticles (AuNPs) stabilized by poly(sulfate) 40 (PS-40). Different AuNP sizes (14, 40 and 80 nm mean diameters) were used to evaluate the response of the sensor. Both colorimetric and Resonance Rayleigh Scattering (RRS) detection schemes. The best results were obtained for the sensor using 40 nm AuNPs, for which the limits of detection (LODs) were found to be 100 nmol L<sup>-1</sup> by the naked eye, 500 nmol L<sup>-1</sup> by the naked eye, values well below the maximum acceptable level of drinking water (1.9 μmol L<sup>-1</sup>) set by the World Health Organization (WHO). The practical use of the 40 nm AuNPs RRS sensor was demonstrated with the determination of CN<sup>-</sup> in drinking and fresh waters. Finally, sensor was successfully implemented in a compact portable device consisting of two light-emitting diodes (LEDs) and a miniature spectrometer, turning this sensor into a very potent tool for its application as a routine field-deployable analytical method.

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### Altitude effect on leaf wax carbon isotopic composition in humid tropical forests

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**Abstract**

The carbon isotopic composition of plant leaf wax biomarkers is commonly used to reconstruct paleoenvironmental conditions. Adding to the limited calibration information available for modern tropical forests, we analyzed plant leaf and leaf wax carbon isotopic compositions in forest canopy trees across a highly biodiverse, 3.3 km elevation gradient on the eastern flank of the Andes Mountains. We sampled the dominant tree species and assessed their relative abundance in each tree community. In total, 405 sunlit canopy leaves were sampled across 129 species and nine forest plots along the elevation profile for bulk leaf and leaf wax  $\delta^{13}C_{org}$  concentration and carbon isotopic anomalies ( $\delta^{13}C_{org}$  vs. a subset of 176 individuals). 29 species

New Phytologist

Research

### The variation of productivity and its allocation along a tropic elevation gradient: a whole carbon budget perspective

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**Summary**

Why do forest productivity and biomass decline with elevation? To address this question research to date generally has focused on correlative approaches describing changes in tree growth and biomass with elevation.

We present a novel, mechanistic approach to this question by quantifying the autotrophic carbon budget in 16 forest plots along a 3300 m elevation transect in Peru.

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New Phytologist

Research

### Leaf-level photosynthetic capacity in lowland Amazonian and high-elevation Andean tropical moist forests of Peru

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**Summary**

We examined whether variations in photosynthetic capacity are linked to variations in the environment and/or associated leaf traits for tropical moist forests (TMFs) in the Andes/western Amazon regions of Peru.

We compared photosynthetic capacity (maximal rate of carboxylation of Rubisco ( $V_{max}$ ) and the maximum rate of electron transport ( $J_{max}$ )), leaf mass, nitrogen (N) and phosphorus (P) per unit leaf area ( $M_L$ ,  $N_L$  and  $P_L$ , respectively), and chlorophyll *a* from 210 species at 18 field sites along a 3300-m elevation gradient. Western blots were used to quantify the abundance of the CO<sub>2</sub>-fixing enzyme Rubisco.

Area- and N-based rates of photosynthetic capacity at 25°C were higher in upland than lowland TMFs, underpinned by greater investment of N in photosynthesis in high-elevation trees. Soil [P] and leaf P<sub>o</sub> were key explanatory factors for models of area-based  $V_{max}$  and  $J_{max}$ , but did not account for variations in photosynthetic N-use efficiency. At any given  $N_L$  and  $P_L$ , the fraction of N allocated to photosynthesis was higher in upland than lowland species. For a small subset of lowland TMF trees examined, a substantial fraction of Rubisco was inactive.

These results highlight the importance of soil- and leaf-P in defining the photosynthetic capacity of TMFs, with variations in N allocation and Rubisco activation state further influencing photosynthetic rates and N-use efficiency of these critically important forests.

Introduction

Tropical moist forests (TMFs) play a significant role in the terrestrial carbon cycle, contributing one-third of global gross primary productivity (Beer et al., 2010; Malhi, 2010). Understanding the factors that regulate leaf photosynthesis ( $A$ ) in TMFs is a prerequisite for modelling carbon storage in tropical ecosystems, with  $A$  being influenced *inter alia* by nutrient supply [particularly nitrogen (N) and phosphorus (P)], elevation and growth temperature.

Early studies in lowland TMFs highlighted low foliar P concentrations as a major influence on light-saturated net photosynthesis

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### Eco-friendly modification of earthen construction with carrageenan: Water durability and mechanical assessment

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**HIGHLIGHTS**

- Carrageenan bioadditives positively modified properties of earthen construction.
- Increases in compressive strength of up to 85% were observed in admixture samples.
- Tensile strength was increased up to 52% according to three-point bending tests.
- Water repellence and erosion resistance were enhanced by using coating treatments.
- Admixtures remained water resistant after 95 days of environmental exposure.

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**ABSTRACT**

Carrageenan, a biodegradable natural polymer, was evaluated as a bioadditive to improve the physical and mechanical properties of adobe constructions. The results show that its incorporation in the mix during blocks fabrication, or as a coating in existent earth constructions, positively modify them both providing water impermeability and resistance to erosion by water drops. Results of mechanical also show a considerable enhancement in compressive and tensile strength when the bioadditive incorporated during the blocks fabrication process. The obtained results show the feasibility of using natural and eco-friendly compounds to modify the behavior of traditional construction materials.

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**1. Introduction**

The development of modern construction techniques is essential to satisfy the needs of housing for our growing societies. However, given the extensive use of natural resources, the construction sector is accountable for the generation of large quantities of wastes and greenhouse gases [1]. The main cause of this pollution is the production of building materials which require the consumption of high amounts of energy and leave a large carbon print [2,3].

In this context, earthen construction represents an attractive traditional alternative for housing since its embodied energy and carbon dioxide (CO<sub>2</sub>) emissions are low. Several authors [4] determined that raw earthen constructions are much less energy consuming and do not generate as much equivalent CO<sub>2</sub> as masonry materials like concrete or steel [2,4,5]. Additionally, the low t of earthen construction and its materials makes it an environment friendly material for massive building, especially in rural areas where often, neither trained workers nor modern materials are available [6].

Despite the advantages of earthen constructions, they present several drawbacks regarding mechanical resistance like poor compressive strength and durability with poor resistance to mold and water attack [6]. From a mechanical point of view, this material presents brittle behavior and low resistance to tensile stress. These facts and the high mass of the resultant buildings, make type of construction system highly vulnerable to seismic events [7]. As a matter of fact, earthen constructions were severely caged during earthquakes in seismic areas as reported in diff

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New Phytologist Research

## Scale dependence of canopy trait distributions along a tropical forest elevation gradient

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**Summary**

- Average responses of forest foliar traits to elevation are well understood, but less is known about trait distributional responses to elevation at multiple ecological scales. This limits our understanding of the ecological scales at which trait variation occurs in response to environmental drivers and change.
- We analyzed and compared multiple canopy foliar trait distributions using field sampling and airborne imaging spectroscopy along an Andes-to-Amazon elevation gradient. Field-estimated traits were generated from three community-weighting methods, and remotely sensed estimates of traits were made at three scales defined by sampling grain size and ecological extent.
- Field and remote sensing approaches revealed increases in average leaf mass per unit area (LMA), water, nonstructural carbohydrates (NSC) and polyphenols with increasing elevation. Foliar nutrients and photosynthetic pigments displayed little to no elevation trend. Sample weighting approaches had little impact on field-estimated trait responses to elevation. Plot representativeness of trait distribution at landscape scales decreased with increasing elevation. Remote sensing indicated elevation-dependent increases in trait variance and distributional skew.
- Multiscale invariance of LMA, leaf water and NSC mark these traits as candidates for trait scaling.

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## Predicting trait-environment relationships for venation networks along an Andes-Amazon elevation gradient

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**Abstract.** Understanding functional trait-environment relationships (TERs) may improve predictions of community assembly. However, many empirical TERs have been weak or lacking conceptual foundation. TERs based on leaf venation networks may better link individuals and communities via hydraulic constraints. We report measurements of vein density, vein radius, and leaf thickness for more than 100 dominant species occurring in ten forest communities spanning a 3,300 m Andes-Amazon elevation gradient in Peru. We use these data to measure the strength of TERs at community scale and to determine whether observed TERs are similar to

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RESEARCH PAPER

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## Assessing trait-based scaling theory in tropical forests spanning a broad temperature gradient

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## Selective adsorption of Pb<sup>2+</sup>, Cr<sup>3+</sup> and Cd<sup>2+</sup> mixtures on activated carbons prepared from waste tires

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**ABSTRACT**

Heavy metal cation mixtures constitute a critical issue facing water treatment. Among available technologies, adsorption is here presented as a selective and effective technology. With this purpose, two adsorbents have been prepared by chemical activation of discarded tires, which in turn, constitute the valorization of a residue from the automotive industry. Two different activating agents ratios by weight (1:1 and 4:1) were employed, and the activated carbons obtained, namely AC-1 and AC-4, were characterized with Scanning Electron Microscopy (SEM), N<sub>2</sub> adsorption-desorption, acid-base titrations, determination of pH<sub>int</sub> and Temperature Programmed Decomposition (TPD). Different textural and acid-base properties were revealed upon different activation conditions, obtaining higher surface area, microporosity and surface acidity for AC-4. The sample AC-1, with lower surface area, consistently led to higher adsorption values for the three cations (Pb<sup>2+</sup>, Cr<sup>3+</sup>, Cd<sup>2+</sup>), indicating that the amount adsorbed was rather governed by type of surface groups present in the adsorbent under the conditions tested. Regarding the amount adsorbed, the sequence Pb<sup>2+</sup> > Cr<sup>3+</sup> > Cd<sup>2+</sup> was measured in individual and mixing conditions, independent of the carbon, and adsorption equilibrium and kinetics were fitted to different models, being Langmuir and pseudo-second order equations the models that better reproduced the equilibrium and kinetic data, respectively.

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## SEM-EDS Study of Ionically Crosslinked Alginate and Alginate Acid Bead Formation

Jorge Ayarza, Yves Coello & Javier Nakamatsu

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## Modulating antioxidant activity and the controlled release capability of laccase mediated catechin grafting of chitosan

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**ABSTRACT**

Laccase from ascomycete *Myceliophthora thermophila* was used for the oxidation and grafting of catechin (CA) and chitosan (CS). The enzymatic grafting of CA into CS resulted in the improvement of material properties of chitosan films. The successful grafting of CA to CS was supported by UV-vis and Fourier transform infrared (FT-IR) spectroscopies. The differences in the molecular weight and the degree of deacetylation of the CS affected on the enzymatic grafting rate and thus on the film properties like swelling behaviour, erosion rate, thermal property, tensile strength and breaking strain. The CS films prepared by enzymatic grafting presented high antioxidant activity compared to native CS films. The controlled release profiles of methylene blue and congo red brilliant blue dye, having different acidity/basicity properties, loaded films were also studied with different release medium. The types of molecule loaded into films, the preparation manner of films and the release medium were decisive parameters affecting the release rate.

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**1. Introduction**

Biological polysaccharides are receiving a growing interest for the antioxidant and antimicrobial functionalisation of materials in food processing, treatment of fibres and medical/pharmaceutical applications [1–3]. Among the various polysaccharides, chitosan is currently the most studied for wound healing and controlled drug carrying materials with diverse forms such as films, beads, gels, scaffolds and nanoparticles. This is due to chitosan's unique property of biodegradability, antibacterial activity, non-inflammatory property, non-toxicity, non-antigenic and high charge density [2,4]. Chitosan is composed of 2-amino-2-deoxy-D-glucose (with free amino groups) and 2-acetamido-2-deoxy-D-glucose (with acetylated amino groups) units linked through β-(1→4) bonds and it is obtained from the alkaline deacetylation of chitin. The properties of chitosan depend mostly on its molecular weight and degree of deacetylation (DDA) [5,6]. The deacetylation of chitosan is a process of hydrolysis of acetamide groups in chitin and normally conducted by severe heterogeneous alkaline treatments due to the resistance of such groups imposed by the trans arrangement of the C2-C3 substituent in the sugar ring [7]. The majority of the biological properties of chitosan is related to its cationic behaviour due to protonation of the amino groups in aqueous acidic solutions. Therefore, the DDA is the most important parameter on the biological activities of chitosan like biodegradability, biocompatibility, mucoadhesion, hemostatic, adsorption enhancer, anticholesterol and antioxidant [6,7].

For wound treatment materials, the reduction potential of reactive oxygen is fundamentally necessary as much as an inhibition capacity to microorganism growth. The reactive oxygen that exists in the pathogenesis of wounds and injuries causes oxidative damage to proteins, nucleic acid, lipids as well as the depletion of mitochondrial DNA from human skin [8–10]. Chitosan has been reported as an effective antimicrobial agent showing high inhibition rate against the microorganism growth [3]. Chitosan possess an antioxidant function but its activity level is very poor due to the lack of a H-atom donor to serve as a good chain breaking antioxidant, especially in the case of medium and high molecular weights

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