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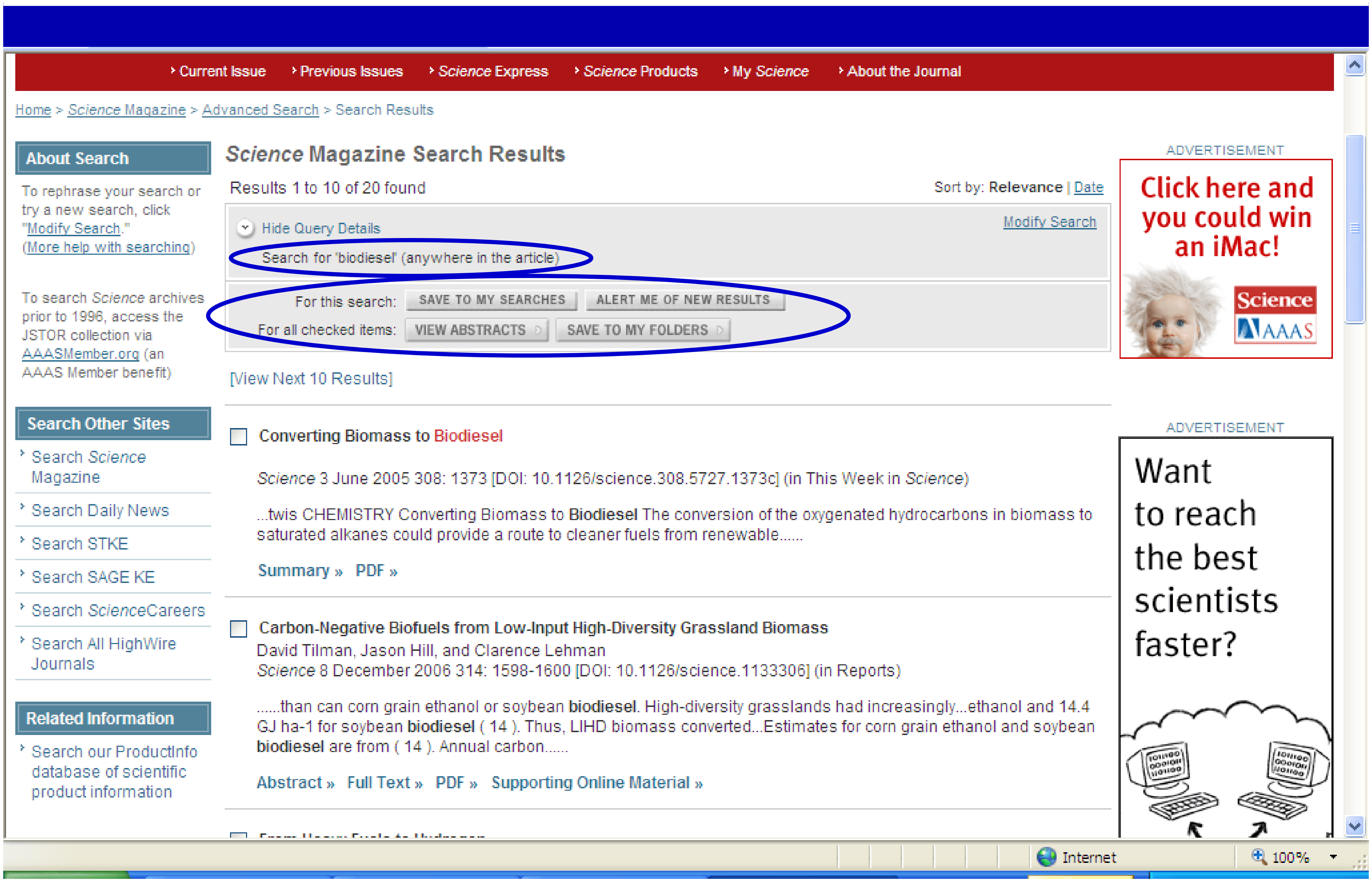
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REPORTS

Renewable Hydrogen from Nonvolatile Fuels by Reactive Flash Volatilization

J. R. Salge, B. J. Dreyer, P. J. Dauenhauer, L. D. Schmidt

Droplets of nonvolatile fuels such as soy oil and glucose-water solutions can be flash evaporated by catalytic partial oxidation to produce hydrogen in high yields with a total time in the reactor of less than 50 milliseconds. Pyrolysis, coupled with catalytic oxidation of the fuels and their fragments upon impact with a hot rhodium-cerium catalyst surface, avoids the formation of deactivating carbon layers on the catalyst. The catalytic reactions of these products generate approximately 1 megawatt of heat per square meter, which maintains the catalyst surface above 800°C at high drop impact rates. At these temperatures, heavy fuels can be catalytically transformed directly into hydrogen, carbon monoxide, and other small molecules in very short contact times without the formation of carbon.

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important process for using renewable fuels such as vegetable oils and liquids produced by hydrolysis or pyrolysis of biomass (1). Hydrogen is needed for fuel cells and for onboard combustion in vehicles for enhanced performance and reduced emissions, and syngas is used for the production of synthetic liquid fuels, chemicals, and fertilizers.

The conversion of gaseous and volatile fuels to H_2 is possible through pyrolysis (1), steam reforming (2), and partial oxidation (3–5), with or without catalysts. However, the direct processing of nonvolatile fuels such as vegetable oils, residual petroleum fuels, and liquid and solid biomass is more complicated because of their tendency to form solid carbon that interferes with process equipment and rapidly plugs pores in heterogeneous catalysts. Such heavy fuels decompose chemically before evaporation to form hydrogen, olefins, aromatics, and solid carbon.

Flash pyrolysis (reaction times typically 1 s) of heavy liquids and solid biomass has been shown (1) to produce primarily gases (syngas) and volatile liquids (bio-oils). Reaction times in these processes are limited by heat transfer into biomass particles to decompose reactants. Additionally, at least ~10% of the reactant biomass is reported to form a solid char that must be separated and removed. Nonvolatile solid biomass pellets have been shown to volatilize without the formation of carbon when exposed to very high heat fluxes (~10^6 W/m^2) (6) of focu… oxid… s can…

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a catalyst-coated ceramic foam maintained at ~800°C by the reaction, it is possible to achieve steady-state operation with refined soy oil, biodiesel (the volatile methyl ester of soy oil), and sugar-water solutions with no external heat supplied. This process produces ~70% selectivity to H_2 with >99% conversion of the fuel. Carbon formation does not occur because the presence of O_2 produces rapid oxidation of decomposition products, and the resulting heat of reaction maintains a surface temperature of 800° to 1000°C that prevents quenching of the process that would lead to rapid carbon formation.

The reactor, sketched in Fig. 1, is similar to those described previously (5) and uses an automotive fuel injector to spray ~400-μm-diameter drops onto a catalyst foam containing Rh-Ce catalyst particles at typically 2.5% by weight of each component. We placed the catalyst ~2 cm from the fuel injector so that the cold drops impinged directly on the front face of the catalyst. Air flowed around the fuel injector to provide a uniform flow field and to optimize mixing with the gaseous products. Air and fuel enter at 20°C; no external heating was needed.

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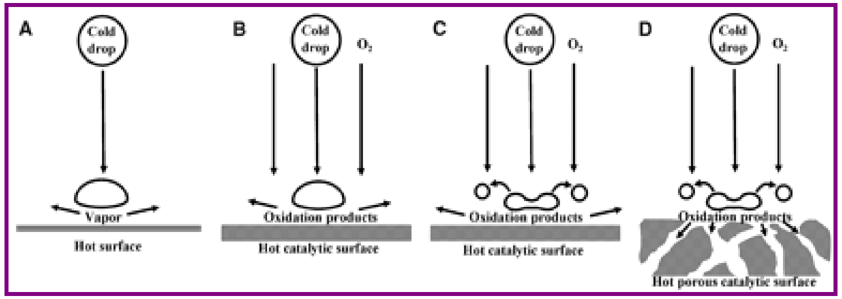

Fig. 3. Sketches of possible configurations of (**A**) conventional film boiling of a volatile drop on a hot surface, (**B**) reactive drop volatilization on a hot catalyst surface, (**C**) dropimpingement and breakup on a hot catalytic surface, and (**D**) drop impingement and breakup on a hot catalytic porous surface. [View Larger Version of this Image (71K JPEG file)]

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experiments, long-term evaluation, and modeling to optimize catalyst performance and determine the exact mechanisms of reactive flash volatilization.

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14. Our system processes approximately 0.6 kg/day of fuel diameter would process ~5.2 kg/day under identical co fuel injectors to obtain sufficiently low flows, but larger injectors, or different methods for uniform drop formatio
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Abstract: The image furnace technology has been applied to the study of the first steps of biomass flash pyrolysis. The experiments performed with small pellets of cellulose show that the reaction primarily passes through the intermediate of short lifetime liquid species (ILC). The quantitative study of the variations of the sample mass loss and of the mass of ILC reveals the existence of a transient period followed by a steady-state regime resulting from an equilibrium between cellulose decomposition into ILC and ILC vaporization. A mathematical model has been solved in parallel. The results agree very well with the experimental measurements and yield additional information on the temperatures of cellulose pyrolysis and of ILC vaporization. (C) 2002 Elsevier Science Ltd. All rights reserved.

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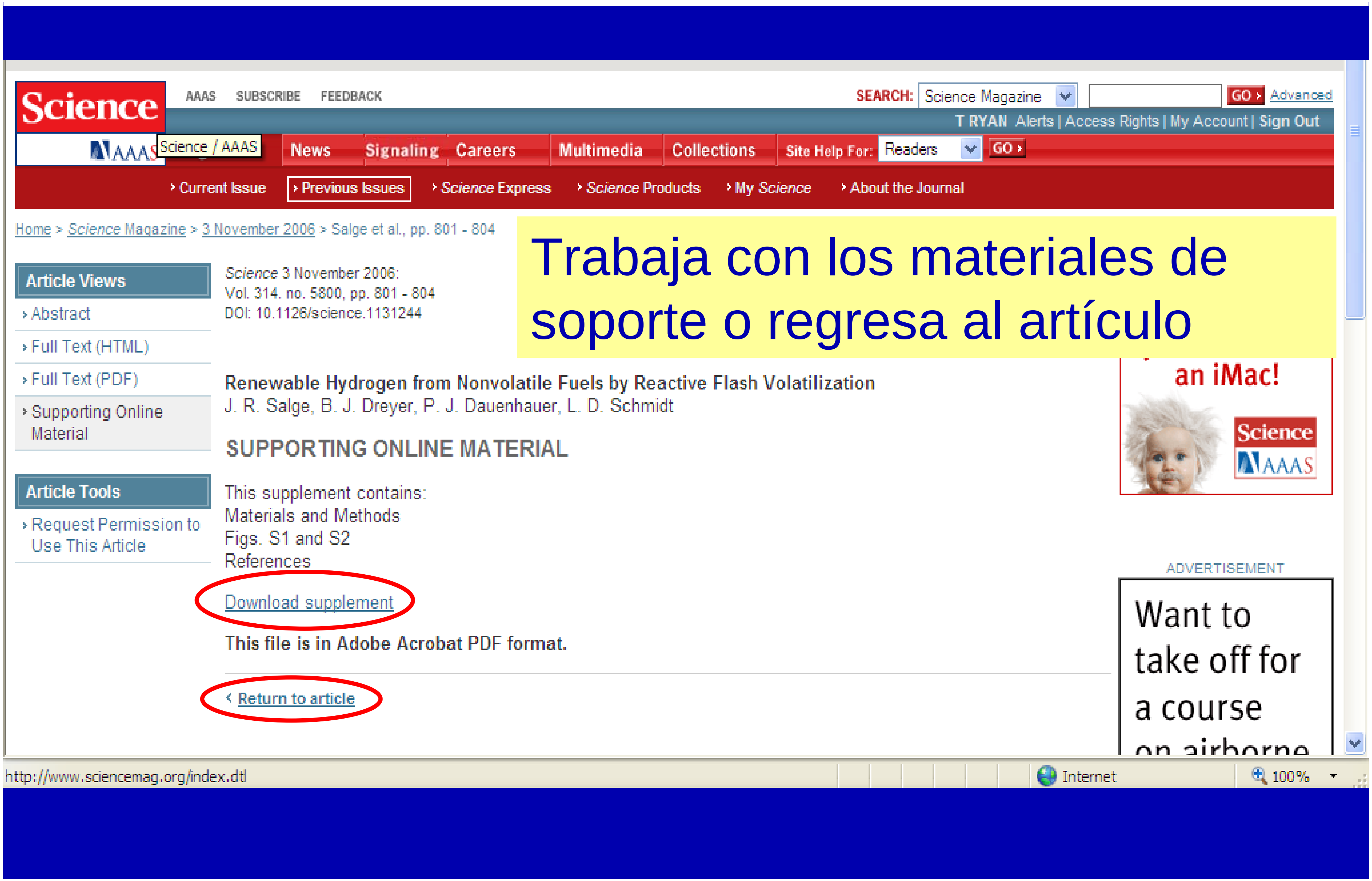

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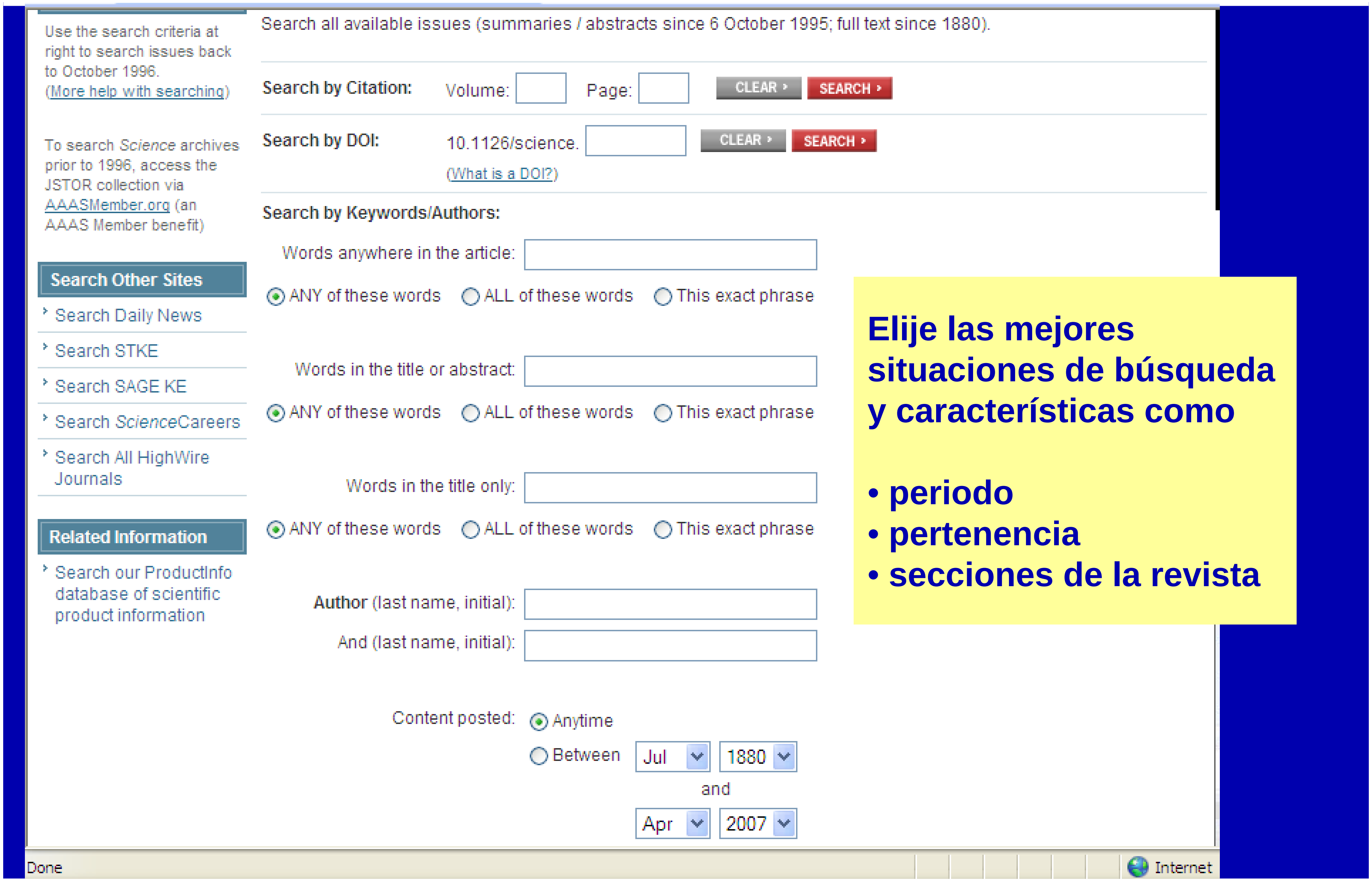

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