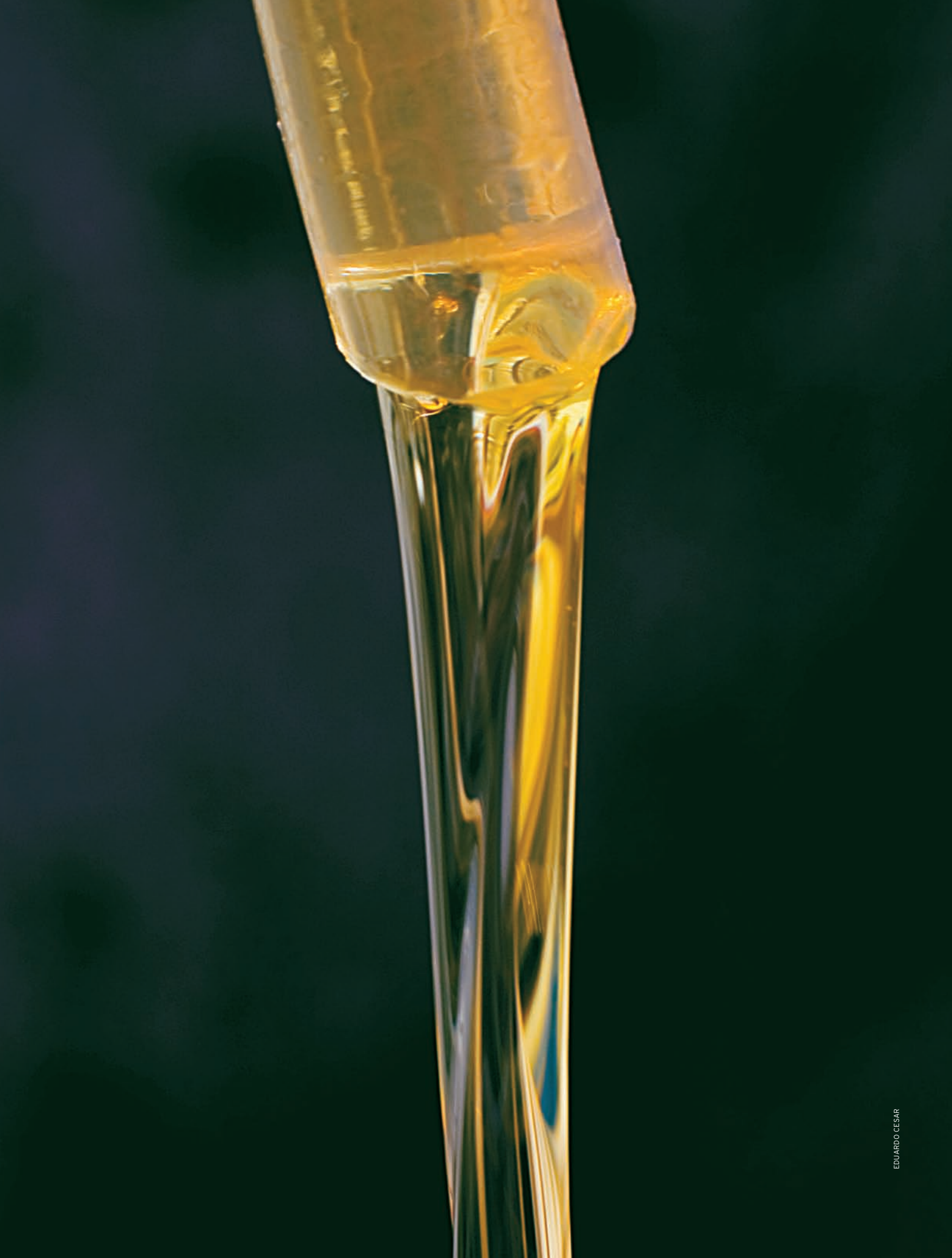

EDUARDO CESAR

ENERGY

Biodiesel on the way up

What remains for this oil to be established as a national biofuel

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Ethanol's companion in the area of renewable fuels, biodiesel, is beginning to become established in Brazil in relation to production and distribution gas stations. By the end of the year the total production should reach 750 million liters, almost the 840 million that the country should produce as of 2008, in order to reach the 2% incorporation quota of this biofuel to diesel derived from petroleum, according to the 2004 Federal Law that established the National Program of Biodiesel Production and Use. Over the last few years, almost three hundred plants have already been constructed or are about to be inaugurated and new production technologies have sprung up. But there is still a lot to do. Almost all of this biofuel produced today in Brazil is not truly renewable because it is made with methanol, an essential raw material for the process of trans-sterification, the chemical reaction that transforms vegetable oil into biodiesel.

Methanol is an alcohol made from natural gas or extracted from petroleum, and therefore non-renewable. The alternative is ethanol, which can be used in this type of reaction. The problem is that to make biodiesel more ethanol than methanol is used. In order to produce 1,000 liters of biodiesel, the plants currently use up to 300 liters of methanol in the production process. In production using ethanol, this number rises to the level of 500 liters of the alcohol made in Brazil from sugarcane. In the two processes, however, residue is around 50% for both types of alcohol, and in a process called excess recovery the residue is led back to the start of the production process. With prices the same, depending on the region where the biodiesel is being produced, producers prefer methanol because of the lower costs.

One of the possibilities that could help with renewable alcohol being incorporated into biodiesel production is a system developed by professor Miguel Dabdoub, from the Clean Technology Development Laboratory (Ladetel) at the University of São Paulo (USP) in the town of Ribeirão Preto. "In Brazil we have the opportunity to use ethanol, but most companies don´t have

The major production of biodiesel is carried out using methanol, made from natural gas, but it could be produced using ethanol

TECBIO

Plant set up by the company Tecbio in Floriano, in Piaui state: Soya and castor bean oils

the technology for this", says Dabdoub. "We developed a process using ethanol with an energy efficient concept in which less alcohol is used, with a large amount of the alcohol recovered at the end of the process and able to be reused." The development of catalysts, substances that accelerate a chemical reaction, in this case based on copper and vanadium, helped with this. "We're drafting out a patent for the catalysts and the new process." As well as the use of ethanol, Dabdoub is proposing a complete set of effluent and residue treatment studies. "If we imagine that the process of producing 2 billion liters of bio diesel in Brazil, would require more than 1 billion liters of water, we must remember that in some way, this water has to be recovered and returned to the process."

But there are those who are against the use of ethanol. "Ethanol's almost a commodity, it's an end product and to use it is contrary to the industrial point of view", suggested the entrepreneur Expedito Parente, a retired professor from the Federal University of Ceará, and author of the first Brazilian biodiesel patent registered in 1977. Currently he is a partner in Tecbio, a company in the state of Ceará that provides plants for the production of biodiesel. For him, ethanol is a top product that should not be used as a raw material. "Principally in the northeast region methanol is cheaper, inspite of being used around 50% less than ethanol", stated professor Parente. "Methanol is basically made from a gas that could be extracted from biomass via the gasification of agricultural residues, even sugarcane bagasse – this is biomethanol."

Invisible flame – For Dabdoub, it is important not to oppose the methanol route because currently it is, from the economic point of view, the most feasible, although it would be equally important to think about a 100% renewable fuel. "In the development process at Ladetel we've also made biodiesel using methanol and the costs are lower, but one needs to say that methanol, as well as not being renewable, causes problems in the production system as there is a greater possibility of contamination and it is highly dangerous: on burning, its flame is invisible, unlike that of ethanol."

"The trans-sterification technique is old, having been developed more than a century ago. It mainly uses methanol because it's a technology developed in the northern hemisphere, where ethanol, until a short time ago, didn't exist in large quantities. This is the moment to `tropicalize` this technology. Methanol is expensive and more toxic, as well as causing many accidents", says the agronomy engineer Décio Luiz Gazzoni, a researcher with Embrapa Soya, a unit, situated in the city of Londrina, in the state of Paraná, belonging to the Brazilian Agricultural Research Corporation. "I believe, through the information I have, that within two years, with public and private investments, we will be able to go ahead in the process of obtaining biodiesel with ethanol. Various groups, – such as those at USP, the Federal University of Paraná, the Federal University of Rio de Janeiro and the Technology Research Institute of Sao Paulo (IPT) – are studying the use of ethanol, a technology more adaptable to the country", he says. "It's a question of details."

Gazzoni, a member of the technical team that drew up the National Agro-Energy Plan, launched by the Ministry of Agriculture in 2003, and also a member of the International Science Panel on Renewable Energies, which makes up part, among other entities, of the International Council for Science (ICSU), believes that the development of biodiesel in Brazil is still in its embryonic phase. "On a world scale as well. The current stage of biodiesel is comparable to that of alcohol in the 1980s. There's still a lot of water to pass under the bridge from the technological point of view, and Brazil, yet again, has advantages when compared to other countries." For him, among those advantages in relation to this biofuel is mainly the strong liaison among sources of scientific knowledge. "We need to make the difference now because we were going down the wrong path, contrary to ethanol. We weren't capable of understanding the importance of biodiesel in the past.`

Gazzoni's argument is made mainly regarding the preparation of growing crops in order to produce vegetable oil. "We need to make more productive growing areas with, for example, the dendê (palm), castor bean, canola, sunflower and even the soya bean, but this takes longer. The main point is to look for greater energetic density in crops before being destined either for human food or animal feed." Gazzoni believes that, at the current stage of these crops, only the dendê oil production of more than 3,000 liters per hectare (l/ha), which could even reach 4,000, will be sustainable in 20 years' time. Nothing comparable, as yet, with good old sugarcane, a gramineous plant, today capable of producing, at least , some 8,000 l/ha.

During a lecture at USP's Advanced Studies Institute in March, Gazzoni pointed out that the world produced 6.2 million tons of biodiesel in 2006 and would need in 2011 a production of 33.5 million and in 2020 some 133.8 million. The increased production comes mainly from Europe where the percentage of biodiesel added to normal diesel will be 5.75% by 2010. Production on the continent reached 3.84 million tons in 2006, previously 6.06 million in 2005, with Germany in the lead for those two years. There, the main oil used comes from canola, previously a European export product, now confined to the continent as a fuel additive for buses, trucks and cars, which also, to a large extent, are driven on diesel. In Europe, biodiesel has been produced industrially since 1992 and its use is relevant at this moment above all because of the need to decrease pollutant gases such as carbon dioxide (CO_2). Various studies indicate that the use of 1 kilo of biodiesel reduces by around 3 kilos the quantity of CO_2 in the atmosphere. The pollution emissions from biodiesel are between 66% to 90% in relation to conventional diesel.

The reality of biodiesel produced today in Brazil basically comes from the soya bean, where the supply and price attract producers, as well as the residue after production of the oil, the so-called soya cake, which has a good market in animal feed as a source of protein. It so happens that soya has physical properties that are not very appropriate or productive for biodiesel. Its seeds yield only 18% of oil, resulting in a production of 700 l/ha. The castor bean, with 47% oil reaches 1,200 l/ha, and the sunflower, with 40%, 800 l/ha. According to Ricardo Dornelles, director of the Renewable Fuel Department of the Ministry of Mines and Energy, soya is the raw material for 55% of the national biodiesel produced up until now. "The castor bean represents 20% and the remainder is divided among other oleaginous crops such as the dendê and forage turnip." For him there is still a long way to go in research, both in the process for the use of ethanol, which requires improving in order to contribute to the industrial costs, and in the development of crops that show greater oil productivity and pest control. "The soya crop has an advantage because the oil production process is well developed and totally dominated by the agro-industry", says Dornelles. "We think that it's also necessary to program and to

The Pinhão Manso is not so tame

Sung in prose and verse as the plant of hope for the abundant production of biodiesel , the pinhão-manso (*Jatropha Cursas*), a common shrub type plant, shows that it is not so tame (*manso* in Portuguese means exactly that: tame). It is still wild – at least within the agricultural perspective. Its large scale cultivation is non-existent and has never been studied in depth. Its domestication is beginning, but it is still too soon to believe in the wonderful tales spread throughout the country, including the sale of seeds via the internet.

The alert was given in the form of a manifesto, in February, by a group of researchers from Embrapa and the Agricultural Research Corporation of Minas Gerais. "We believe in the future potential of the plant, but our technical knowledge is limited because we are not familiar with various planting parameters, such as the spacing between plants, the production of offshoots, and principally pests and illnesses", says the researcher Liv Soares Severino, from Embrapa Cotton, located in the city of Campina Grande, in the state of Paraíba.

"One of our concerns is that many farmers have been investing in the plant and after two or three years will come to us so that we can resolve problems with the crop. And as yet we don't know it from the agricultural point of view." Severino, by means of a project financed by Petrobras, went with other Brazilian researchers to India, where it was said that the cultivation of the *Jatrpoha Cursas* had already been developed. "We discovered that they know as little about it as we do." One of the problems indicated is harvesting. The plant has the advantage of being long lasting, or that is, it doesn't need to be planted every year, but the fruit don't mature at the same time. One needs to harvest manually various times and with this the cost of the crop increases.


EMBRAPA

In relation to the quantity of oil, it was estimated at more than 1,000 liters per hectare, but Severino says that it does not go beyond 400 l/ha, although there is potential to increase this quantity considerably. Before biodiesel, the pinhão-manso was relegated to a backyard plant or for a mere curiosity or personal appreciation. But it has previously lived through more memorable times, when in the 19th century its oil, like that of other sources, such as the whale, for example, was used to illuminate the streets of Rio de Janeiro.

carry out the zoning of crops in such a way that they become more productive in determined regions."

The castor bean, for example, occupies second place principally because of incentives to producers in the Northeast region. The social seal established by the National Biodiesel Program is given to production that comes from initiatives considered family agriculture, and eliminates taxes for the producers of this plant in the North, Northeast, and semi-arid regions. Petrobrás, aiming to perform in this sense by buying castor bean and sunflower seeds from small farmers, has established a biodiesel production unit at Guamaré Polo, in the state of Rio Grande do Norte .

General extraction – Plant alternatives for producing vegetable oils are not lacking throughout the world, principally in the planet's tropical belt. But even in cold areas such as the Patagonia region, in Argentina, there are already initiatives to produce biodiesel from the oil of seaweed. In March, the website of the Science and Development Network, SciDevNet, announced an Argentine company headed by Oil Fox, had made an agreement with the local government to cultivate seaweed in huge ponds in the province of Chubut. With German investment of US$ 20 million, the company announced that it hopes to produce 240,000 tons of marine biodiesel annually on only 300 hectares compared to the 600,000 hectares that would be needed for the production of Soya.

In Brazil many alternatives still exist such as babassu, peanuts, cotton seed, souari nut and the pinhão-manso [*Jatropha Cursas*] (*see box*), for example, not counting other Amazonian plants not yet well established. Many things have already been tried. "Between 1977 and 1980, when we tested various raw materials, a passion fruit juice producer from the state of Ceará named Agrolusa, asked us to try producing diesel using the seeds of this fruit", recalls Expedito Parente, from Tecbio. "It went well, and his company's Kombi vans ran for six months on this diesel. But after they verified that the price paid by the cosmetic industry for the oil from the passionfruit seeds was worth much more ."

Another curious experience by Parente in the first days of biodiesel in Brazil was the production of biofuel from sardine oil. "I received from a Belgian firm 200 liters of fish oil that proved to be good for producing biodiesel." Animal fat or tallow, both from bovine and chickens and pigs, are also currently on the producers' route using the same trans-sterification process. "In Brazil there is the annual availability of 700,000 tons of bovine tallow for the production of biodiesel, a product that stopped being a residue and transformed itself into a byproduct", says Carlos Freitas, a consultant and partner with the firm Conatus Bionergia, which is preparing to install a biodiesel plant in the north of the state of Paraná, with a production capacity of 200 tons per day, starting off with soya and sunflower seeds. "Animal fat is important, but, because of the quantity offered, it will always remain on the margin of vegetal oils."

Although so new, the biodiesel industry in Brazil is already exporting technology. Dabdoub, from USP, has already provided consultancy for two biodiesel plants that were built in the United States. One of them in the town of Gilman, in Illinois, belongs to the Brazilian entrepreneur Renato Ribeiro who produces soya oil on American soil. It has a capacity of 110 million liters per year and uses ethanol extracted from corn. In this enterprise, US$ 2 million in equipment was exported from Brazil to the United States. At another plant in Durant, in Oklahoma, Dabdoub only transferred knowledge in the form of consultancy. The plant is under construction and will only use Brazilian equipment, possibly during a second stage.

During the elaboration of this job, Dabdoub received an offer of an agreement to study biodiesel between the Oklahoma State University and Texas State University, in partnership with the Brazilian Chemistry Society and its American counterpart. The interaction is going to benefit students by way of

PETROBRAS

Petrobras' experimental production unit at Guamaré, in the state of Rio Grande do Norte

traineeships between the two countries. For the researcher, this is a two-way path. "Knowledge is not delivered, it is exchanged", suggests Dabdoub, who is also the president of the Biofuels Chamber of the government of the State of Sao Paulo.

Pilot plant – The partnership and interaction with the academic world is also in sight of the company Marchiori, which has developed equipment, such as tubing, tanks and reactors for biodiesel plants made of fiberglass instead of the traditional steel, which cost, according to the production engineer, Antonio Martinho Marchiori, a company partner, from 30 to 40% less than those currently used. "We have a patent for the equipment and one for the biodiesel production process using fiberglass equipment", says Marchiori, who donated a pilot plant, which produces 200 liters per day, to the Biofuels National Polo that functions at USP's Luiz de Queiroz Upper School of Agriculture. "We're doing the same thing with the São Paulo State University (Unesp), in the town of Ilha Solteira. In both cases, we intend, with the studies that are being carried out, to obtain improvements in our plants in areas that the university can collaborate with, such as automation and information technology use."

Another mega-partnership recently finalized, whose results were presented to the Ministry of Science and Technology in March, was the approval of tests for mixing 5% biodiesel with diesel. The National Association of Vehicle Manufacturers (Anfavea), car parts companies, as well as the Technology Development Institute (Lactec) of Curitiba, in the state of Paraná, the Technology Research Institute (IPT) and Unesp at Jaboticabal all took part. With this, the government and the vehicle manufacturers can adopt the 5% programmed for 2010. "There were 140 trucks, as well as tractors, which ran thousands of kilometers and, when we opened up the motors, we verified excellent durability, better lubrication", says Dabdoub, who coordinated the studies. "The manufacturer of the Valtra tractors is already thinking about giving a guarantee of up to 20% of biodiesel."

Similar tests were finalized in August of 2006 for the French group PSA Peugeot Citroën, which were carried out by

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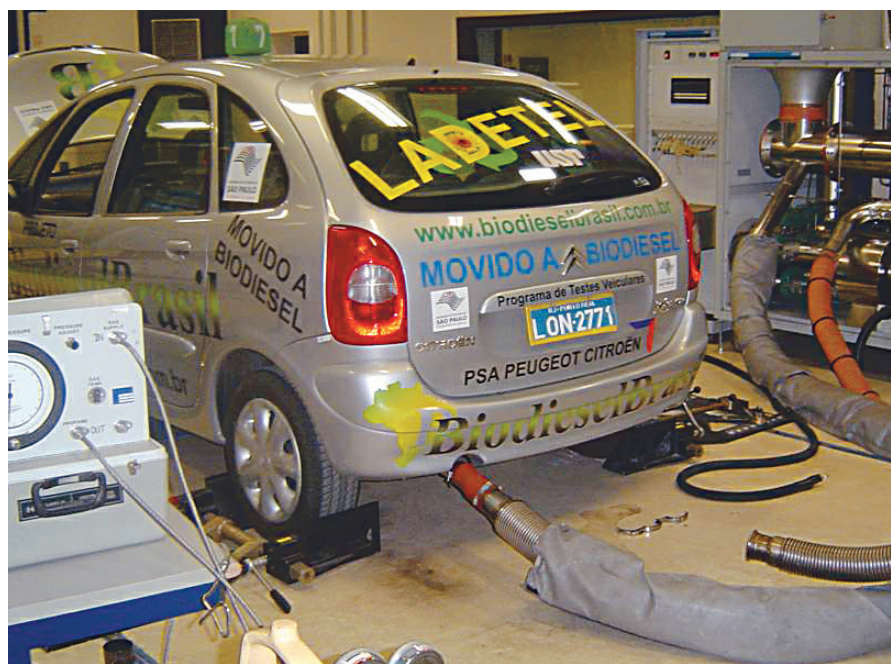
The firm Marchiori is betting on fiberglass to bring costs down

Dabdoub' team in conjunction with Lactec. A Peugeot 206 and a Xsara Picasso, with diesel motors, common in Europe, ran for more than 110,000 kilometers, as well as doing some laboratory tests with 30% biodiesel, and showed excellent results. "We used oil from the dendê oil, soya and castor bean, in different proportions, and ethanol in the oil's production."

For Dabdoub there is still an extensive area of research linked to biodiesel. One of them is called enzymatic catalysis – which is happening in the same way as the Brazilian research studies, and those outside the country, using sugarcane bagasse or residues for the extraction of ethanol.

In the biodiesel case, the objective is to remove more oil from the residues of soya and castor bean oil production and from the other plants used in the production of vegetal diesel oils. "We've already managed this, but the method is not yet competitive", says Dabdoub. He also says that glycerin – a product resulting from the trans-sterification process that is sold to the chemical, pharmaceutical and cosmetic industries – could be used as a new energy resource within the biodiesel plant. It generates electrical energy by producing steam to run turbines, as is done with sugarcane bagasse in the sugar/alcohol distilleries. "But it would only be viable when it falls to 70% of the current value of diesel derived from petroleum used for burning in boilers or for heating in cold ccountries, compensating, in this way, the lower calorific value of glycerin with a lower price also. In the current scenario, as the price of glycerin has reached some US$ 700 per ton, using it in boilers to generate energy is still not viable." ■



LADETEL/LACTEC

At Lactec, in Curitiba, inside the laboratory testing a car running on 30% biodiesel